97th NARST International Conference | Program

March 17-20, 2024

SCIENCE EDUCATION for the REST OF US

Coming together to reflect on global science education reforms

Denver, Colorado – Sheraton Denver Downtown

THANK YOU TO OUR SPONSORS

COLORADO

ctac | COMMUNITY TRAINING AND ASSISTANCE CENTER

NCSE National Center for Science Education

ODU Darden College of Education and Professional Studies

PhET INTERACTIVE SIMULATIONS University of Colorado Boulder

SeeMeTeach™ Teacher Observation Reimagined!

Springer

vosaic™

WILEY

We acknowledge Wiley and their work as publisher of the *Journal of Research in Science Teaching – JRST*.

97th NARST International Conference

Please note that this program is subject to change.

Check the addendum posted at the meeting and on the NARST website for updates.

Table of Contents

2 Sponsors
3 Table of Contents
4 NARST General Information
5 Code of Ethical Conduct
7 Research Interest Groups (RIGs) Information
9 NARST Leadership Team
10 Strand Key
10 Strand Coordinators
11 Program Proposal Reviewers
15 NARST Presidents & Executive Directors
16 *JRST* Editors & NARST Emeritus Members
17 NARST Awards
- 17 Distinguished Contributions to Science Education through Research
- 18 Outstanding Doctoral Research Award
- 19 Early Career Research Award & NARST Fellows
- 20 *JRST* Award
- 21 Outstanding Paper Award
- 22 Outstanding Master's Thesis Award & Classroom Applications Award

23 NARST Standing Committees
30 Sponsorship Program for Graduate Student Memberships
34 2025 NARST International Conference
37 Sheraton Denver Downtown Floor Maps

---

19 NARST Future Meeting Dates

97th NARST International Conference

General Information

Information about NARST

NARST is a global organization for improving science teaching and learning through research. Since its inception in 1928, NARST has promoted research in science education and the communication of knowledge generated by the research. The ultimate goal of NARST is to help all learners achieve science literacy.

The Association is incorporated as a non-profit corporation in the State of Minnesota. The official publication is the *Journal of Research in Science Teaching (JRST)*. NARST encourages presentations of a wide variety of investigations in all aspects of science education, including action, historical, philosophical, ethnographic, experimental, and evaluative research studies. Reports of empirical research, critical reviews, and theoretical works are encouraged. In October 2010, to reflect the Association's growing international focus and membership, the Board approved referring to the Association by its acronym only. At the April 2011 Board Meeting, the tagline for the Association was approved by the Board. Thus, the Association's name and tagline is:

NARST— A global organization for improving science education through research.

Research areas of interest to NARST members include curriculum development and organization, assessment and evaluation, learning theory, teacher education, programs for exceptional students (special needs and talents), equity studies, policy, and methods of teaching.

NARST Mission Statement

NARST is a global organization of professionals committed to the improvement of science teaching and learning through research. Since its inception in 1928, NARST has promoted research in science education and the communication of knowledge generated by the research.

The ultimate goal of NARST is to help all learners achieve science literacy. NARST promotes this goal by: **1)** encouraging and supporting the application of diverse research methods and theoretical perspectives from multiple disciplines to the investigation of teaching and learning in science; **2)** communicating science education research findings to researchers, practitioners, and policy makers; and **3)** cooperating with other educational and scientific societies to influence educational policies.

Member Benefits

- Ten issues of the Journal of Research in Science Teaching (JRST) are published each volume year. JRST has been ranked as one of the highest quality educational journals according to studies published by War, Holland and Schramm (American Educational Research Journal) and Guba and Clark (Educational Researcher) for the American Educational Research Association (AERA). These authors identified JRST as clearly the top research journal in science education.
- Website, Member Portal and Listserv, allowing access to further information about the Association. You may access this site at: http://www.narst.org. There is further information about subscribing to the listserv on this site.
- Opportunities to participate in monthly webinars.

Code of Ethical Conduct

The purpose of the National Association of Research in Science Teaching (NARST) Code of Ethical Conduct is to articulate a set of aspirational principles to guide and support members as they engage in professional activities—research, teaching, and service. NARST members are science education professionals who include researchers, practitioners, and graduate students from various cultures worldwide. These aspirational principles align with and support the mission of the organization to help all members achieve, develop, and contribute meaningfully to the improvement of science teaching and learning through research. NARST expects its members to adhere to the highest ethical standards. The Code of Ethical Conduct serves as a guide to the everyday professional conduct of science educators.

Unfamiliarity with NARST's Code of Ethical Conduct is not a valid defense for engaging in or failing to challenge observed unethical behavior. We accomplish this through our Code of Ethical Conduct where there is:

A. Professional Competence

Science education professionals strive to maintain the highest levels of competence in their work; they recognize the limitations of their expertise; and they undertake only those tasks for which they are qualified by education, training, or experience. They recognize the need for ongoing education in order to remain professionally competent; and they utilize the appropriate scientific, scholarly, professional, technical, and administrative resources needed to ensure honesty and integrity. Science education professionals conduct research, teach, practice, and provide service only within the boundaries of their competence, based on their education, training, supervised experience, or appropriate professional experience. They consult with other professionals when necessary for the benefit of their students, research participants, and clients. They maintain awareness of current scientific, scholarly, and professional information in their fields of activity and undertake continuing efforts to maintain competence in the skills they use. Importantly, professional competence must also include a willingness to accept and integrate new information and experiences, regardless of the effect that process has on research outcomes.

B. Integrity

It is the social responsibility of science education professionals to maintain integrity in all conduct, publications, and forums, and give due credit to the contributions of others. Adhering to this standard means science education professionals do not fabricate, falsify, or plagiarize. Public comments on matters of importance that are relevant to science education must be made with care and accuracy. Adhering to this standard means science education professionals do not use deficit language, deceptive statements concerning research data, or otherwise knowingly make false, misleading or deceptive statements in practicing and presenting research. Comment and debate within the bounds of collegiality and professionalism that keep the organization moving forward and current with emergent issues and perspectives are encouraged. Adhering to this standard means science education professionals do not use dismissive remarks or gestures, restrict multiple voices, or use derogatory language. In short, science education professionals conduct their professional activities in ways that engender trust and confidence.

C. Professional and Scholarly Responsibility in Science Teaching, Learning, and Research

Science education professionals have a responsibility to use research practice and policy to advance NARST members' understanding of the teaching and learning of science in all learning contexts—formal, informal, local, and global—through research, practice, and policy. They adhere to the highest scholarly and professional standards within their field of expertise and accept responsibility for adherence to those standards. Science education professionals should regard the tutelage of graduate students and early career faculty as a trust conferred by the organization for which they work, as well as NARST, for the promotion of these individuals' learning and professional development.

Science education professionals understand that they form a community and show respect for other science education professionals even when they disagree on theoretical, methodological, or personal approaches to professional activities. In activities involving marginalized populations, it is essential that responsible science education professionals seek out the voices and experiences of members of these groups and treat them as critical to their scholarship. While always endeavoring to be collegial, science education professionals must never let the desire to be collegial outweigh their shared responsibility for ethical behavior. When appropriate, they consult with colleagues, NARST's Equity and Ethics Committee, or organizational entities such as their institutional review board in order to prevent, avoid, or challenge unethical conduct.

D. Respect for People's Rights, Dignity, and Diversity

Science education professionals respect the rights, dignity, and worth of all people in their professional activities. They treat other professionals, students, research participants, and members of the organization fairly, respectfully, and without exploitation or harassment. Science education professionals acknowledge the rights of others to hold values, attitudes, and opinions that differ from their own and take reasonable steps to avoid harm to others in the conduct of their work. They learn with others, share ideas honestly, give credit for others' contributions, and encourage others to contribute their unique skills, knowledge, and interests in professional environments. Science education professionals are sensitive to cultural, individual, and role differences in teaching, studying, and providing service to groups of people with distinctive characteristics, as well as the power differential that might result from such differences.

Science education professionals carefully avoid discrimination and bias toward individuals and groups based on race, gender, age, religion, ethnicity, nationality, sexual orientation, gender expression, gender identity, presence of disabilities, educational background, socioeconomic status, or other personal attributes. They refrain from making biased assumptions about others and perpetuating demeaning attitudes and stereotypes. Science education professionals do not accept any forms of discrimination and actively challenge implicit and explicit forms of discrimination.

E. Social Responsibility

Science education professionals are aware of their scientific and professional responsibility to the communities and societies in which they live. This awareness extends to their involvement and service to an increasingly diverse and international NARST community. NARST members are guided by the values and standards that reflect the professional literature. They strive to promote equity and the public good by advancing scientific and scholarly knowledge. Science education professionals are aware of the differences in society and culture that impact scholarly knowledge and academic work. They value and embrace the public trust in research and teaching and are concerned about their ethical behavior and the behavior of other science education professionals that might compromise that trust. Science education professionals should reasonably expect of themselves and others to be guided by a code of ethics that supports efforts to resolve ethical dilemmas.

References

AERA Council. (2011). Code of ethics: American Educational Research Association. Educational Researcher, 40(3), 145-146.

American Sociological Association. (1999). Code of ethics and policies and procedures of the ASA committee on professional ethics. Retrieved from: http://www.asanet.org/membership/code-ethics

American Psychological Association. (2017). Ethical principles of psychologists and code of conduct. Retrieved from: https://www.apa.org/ethics/code/

Research Interest Groups (RIGs) Information

Continental and Diasporic Africa in Science Education RIG (CADASE)

The purpose of CADASE RIG is to **(a)** encourage science educators to engage in research aimed at meeting the needs of people of African descent; and **(b)** provide intellectual, professional, and personal space for science educators engaged in such research. This RIG will provide opportunities for science education researchers to integrate the study of culture, ethnicity, gender, race, and social class as lenses for performing critical analyses and evaluations of prevailing theory and practice of science education on the lives of people of African descent. A variety of theoretical and methodological frameworks will be used to address issues in science curriculum, learning, teaching, assessment and evaluation, and policy issues in both K-14 formal and informal venues in different contexts.

Chair: **Mary M. Atwater**
atwater@uga.edu

Steering Committee Chair: **Rona Robinson-Hill**
rmrobinsonhi@bsu.edu

Secretary: **Shari Earnest Watkins**
shariear@yahoo.com

Treasurer: **Brittany Gavin-Hudson**
bagarvin@gmail.com

LATINO/A RIG (LARIG)

The Latino/a RIG supports social networks that further research agendas regarding Latino/a science learners. LARIG also serves as a support and mentoring alcoba (space) for Latin@s/Latino science educators and others interested in Latin@ science education.

Chair: **Regina L. Suriel**, Valdosta State University
rlsuriel@valdosta.edu

Contemporary Methods for Science Education Research

The broad purpose of this RIG is to advance the mission of NARST by maintaining the rigor of science education studies, as well as promoting more standardized research practices across the organization such that we are better able to learn from and synthesize each other's work. The intent is that these outcomes will, in turn, allow us to keep advancing the field and maintain the relevance of our research to improving science teaching and learning.

Chair: **Robert Talbot**, University of Colorado - Denver
robert.talbot@ucdenver.edu

Co-Chair: **Bina Vanmali**, Arizona State University
bina@asu.edu

Engineering Education RIG (ENE-RIG)

The purpose of the RIG in Engineering Education is to synergize research in science and engineering education, promote rigorous research in engineering education, and provide a collaboration and discussion space supporting intellectual and professional exchange and networking.

Chair: **Anne Emerson Leak**, High Point University
aleak@highpoint.edu

Indigenous Science Knowledge Research Interest Group (ISK-RIG)

The ISK-RIG was set up to showcase and provide support to current and future research works of a growing number of Indigenous Knowledge Systems (IKS) researchers working within indigenous communities throughout the world who are members of NARST. This group includes active members from Africa and the African Diaspora, Alaska, Australia, Canada, Indigenous populations of the Americas, Asia and the Pacific, the Middle East, Thailand, Nordic Regions, New Zealand, Scandinavia, the West and East Indies, etc. The goal is to increase awareness of what indigenous knowledge systems can contribute to research.

Chair: **Bhaskar Upadhyay**, University of Minnesota
bhaskar@umn.edu
Secretary: **Cikigaq-Irasema Ortega**, University of Alaska, Anchorage
iortega2@uaa.alaska.edu
Treasurer: **Sharon Nelson-Barber**, WestEd
snelson@wested.org

Research in Artificial Intelligence-Involved Science Education (RAISE)

This RAISE RIG aims at employing AI to extend the landscape of science education, increase the capacity of all participants in the venture to face worldwide challenges, and significantly address the equity and ethical problems in the world broadly. This RIG will **(a)** support cutting-edge innovations using AI to address learning, teaching, assessment, equity and policy issues in science education; **(b)** communicate the cutting-edge research involving AI to all researchers, practitioners, and policymakers; and **(c)** encourage junior scholars in the field to pursue AI innovations within science education research as it is broadly practiced.

Chair: **Xiaoming Zhai**, University of Georgia
Xiaoming.zhai@uga.edu
Co-Chair: **Kent J. Crippen**, University of Florida
kcrippen@coe.ufl.edu

Asian and Pacific Islander Science Education Research (APISER)

The APRSER RIG will promote diversity, equity, and inclusion in science education research using the lenses relevant to Asian and pacific islander cultures, ethnicities, gender, and class, as well as the intersections of these markers. It will also serve as an intellectual network to support and mentor current and future Asian and Pacific Islander scholars within and outside of the United States, including NARST members interested in API related research endeavors.

Dr. Ling Liang
liang@lasalle.edu
Dr. Xiufeng Liu
xliu5@buffalo.edu

Lesbian, Gay, Bisexual, Transgender, Queer, Plus Science Education Research Group (LGBTQ +)

This RIG provides opportunities for science education researchers to explore and discuss issues relevant to the LGBTQ+ community related to a wide range of topics including science curriculum, learning, teaching, assessment or evaluation, and policy issues in both K-16 formal and informal educational contexts. RIG members promote diversity, equity, and inclusion in science education and science education research. The LGBTQ+ RIG serves as a peer support, mentoring, and inclusive space for folks who identity as LGBTQ+. The LGBTQ+ RIG provides a formalized space inclusive of queer folk and queer research.

Dr. Colby Toefel-Grehl, Utah State University
colby.tg@usu.edu
Dr. Sara Porter, University of North Carolina at Greensboro
scheredi@uncg.edu

2023–2024 NARST Leadership Team

Officers and Board of Directors:

President
Jomo Mutegi (2025)
Old Dominion University

President-Elect
Jerome Shaw (2026)
University of California, Santa Cruz

Immediate Past President
Gillian Roehrig (2024)
University of Minnesota

Secretary-Treasurer
Brooke Whitworth (2026)
Clemson University

Executive Director
Lisa Martin-Hansen (2024)
California State University – Long Beach

Executive Board Members:

Malcolm Butler (2024)
University of North Carolina, Charlotte

Patrick Enderle (2026)
Georgia State University

Amelia Wenk Gotwals (2025)
Michigan State University

S. Selcen Guzey (2026)
Purdue University

Shiang-Yao Liu (2026)
National Taiwan Normal University

Scott McDonald (2024)
Pennsylvania State University

Sharon Nelson-Barber (2025)
WestEd

Senay Purzer (2024)
Purdue University

International Coordinator

Mercy Ogunsola-Bandele (2025)
National Open University of Nigeria

Graduate Student Coordinator

Jennifer Bateman (2025)
Clemson University

NARST Liaison to NSTA

Michael G. Bowen (2024)
Mount Saint Vincent University

JRST Editors

Felicia Moore Mensah (2025)
Teachers College, Columbia University

Troy Sadler (2025)
The University of North Carolina at Chapel Hill

Strand Key

Strand 1:	**Science Learning: Development of Student Understanding**
Strand 2:	**Science Learning: Contexts, Characteristics, and Interactions**
Strand 3:	**Science Teaching—Primary School: Characteristics and Strategies** (Grades PreK-6)
Strand 4:	**Science Teaching—Middle and High School: Characteristics and Strategies** (Grades 5-12)
Strand 5:	**College Science Teaching and Learning** (Grades 13-20)
Strand 6:	**Science Learning in Informal Contexts**
Strand 7:	**Pre-service Science Teacher Education**
Strand 8:	**In-service Science Teacher Education**
Strand 9:	**Discontinued**
Strand 10:	**Curriculum, Evaluation, and Assessment**
Strand 11:	**Cultural, Social, and Gender Issues**
Strand 12:	**Technology for Teaching, Learning, and Research**
Strand 13:	**History, Philosophy, Sociology, and Nature of Science**
Strand 14:	**Environmental Education and Sustainability**
Strand 15:	**Policy, Reform and Program Evaluation**

2023-2024 Strand Coordinators

Strand 1: Science Learning—Development of Student Understanding

Xiaoming Zhai (2024)
University of Georgia

Daniela Fiedler (2025)
Leibniz Institute for S&M Education

Strand 2: Science Learning—Contexts, Characteristics and Interactions

Patricia Patrick (2024)
Columbus State University

Anne Emerson Leak (2025)
University of California Santa Barbara

Strand 3: Science Teaching—Primary School (Grades preK-6)

Karl Jung (2024)
University of South Florida

Jing Lin (2025)
Beijing Normal University

Strand 4: Science Teaching—Middle and High School (Grades 5-12)

Elizabeth Lewis (2024)
University of Nebraska-Lincoln

Emily Adah Miller (2025)
University of Georgia

Strand 5: College Science Teaching and Learning (Grades 13-20)

Anita Schuchardt (2024)
University of Minnesota

Tara Nkrumah (2025)
Arizona State University

Strand 6: Science Learning in Informal Contexts

Neta Shaby (2024)
Ben Gurion University of the Negev

Rebecca Swanson (2025)
University of Nebraska-Lincoln

Strand 7: Pre-service Science Teacher Education

Amal Ibourk (2024)
Florida State University

Preethi Titu (2025)
Kennesaw State University

Strand 8: In-service Science Teacher Education

Julie Bianchini (2024)
University of California, Santa Barbara

Quentin Biddy (2025)
University of Colorado

Strand 10: Curriculum and Assessment

Tejaswini Dalvi (2024)
University of Massachusetts, Boston

Peng He (2025)
Michigan State University

Strand 11: Cultural, Social, and Gender Issues

Kathryn Kirchgasler (2024)
University of Wisconsin-Madison

Sophia Jeong (2025)
University of Georgia

Strand 12: Technology for Teaching, Learning, and Research

Richard Lamb (2024)
East Carolina University

Yang Yang (2025)
Qingdao University

Strand 13: History, Philosophy, Sociology, and Nature of Science

Jacob Pleasants (2024)
University of Oklahoma

Allison Antink-Meyer (2025)
Illinois State University

Strand 14: Environmental Education and Sustainability

Wardell A. Powell (2024)
Framingham State University

Narendra Dadarao Deshmukh (2025)
Homi Bhabha Centre for Science Education

Strand 15: Policy, Reform, and Program Evaluation

Felicia Leammukda (2024)
St. Cloud State University

Jamie Mikeska (2025)
Educational Testing Research

Program Proposal Reviewers

Gili Ad-Marbach
Akira Adachi
Emily Adah Miller
Matt Adams
Ibukunolu Ademola
Isabell Adler
Deborah Oluwatosin Agbanimu
Emily Tancredi-Brice Agbenyega
Vered Alboher Agmon
Hendra Agustian
Uchechi Ahanonye
Raju Ahmmed
Wanjoo Ahn
Junhwan Ahn
Zeynep Akdemir
Valarie Akerson
Selin Akgun
Joshua Akinpelu
Sule Aksoy
Büşra Aksöz
Sahar Alameh
Nabeh Alatawna
Winter Allen
Zahrah Almasabi
Carolina Alvarado
Syahrul Amin
Sage Andersen
Justin Andersson
Tasneem Anwar
Xornam Apedoe
Sandra Arango-Caro
Anna Arias
Tulana Ariyaratne
Dhanya Attipetty
Farnaz Avarzamani
Ehud Aviran
Sheikh Tahmina Awal
Amdad Ahmed Awsaf
Kate Ayers
Olalekan Badmus
Jessica Bailey
Meena Balgopal
Doug Ball
Mercy Bandele
Eric Banilower
Hanhui Bao
H. Prentice Baptiste
Ayelet Baram-Tsabari
Divya Baranwal
Elizabeth Barnes
Mo Basir
Alicia Batailles
Jess Bautista
Breanna Beaver
Kelsey Beeghly
Sarah Belson
Amanda Benedict-Chambers
Onuorah Benjamin
Matthew Bennett
Adam Bennion
Lillian Bentley
Tess Bernhard
Christine Hirst Bernhardt
Arne Bewersdorff
Richard Bex
Petra Bezeljak
Srinjita Bhaduri
Charlie Blake
Margaret Blanchard
Matthew Blank
Tom Bleckmann
Damaries Blondonville
Yurdagul Bogar
Franz Bogner
Scott Bonham
Lisa Borgerding
Janne-Marie Bothor
Saouma BouJaoude
Jonathan Bowers
Bonnie Boyd

Program Proposal Reviewers

Katie Boyd
Tugba Boz
Allison Bradford
Linsey Brennan
Dirk Brockmann-Behnsen
Leslie Brown
Julie Brown
Michelle Brown
Samuel Bullard
Muhammad Abd Hadi Bunyamin
Terrance Burgess
Shondricka Burrell
Cory A Buxton
Scott Byrd
Ryan Cain
Mustafa Cakir
Aylin Cam
Marti Canipe
Daniel Capps
Monica Cardella
Heidi Carlone
Janet Carlson
Sarah Carrier
Carmen Carrion
Grace Carroll
Ingrid Carter
Ira Caspari
Aramati Casper
Michael Cassidy
Sheila Castro
Logan CC
Gaye Ceyhan
Devasmita Chakraverty
Laura Chalfant
Eirini Chatzara
Jessica Chen
I-Chien Chen
Kevin Cherbow
Kason Ka Ching Cheung
Ying-Chih Chen
Gina Childers
Doris Chin
Mei-Hung Chiu
Meghna Nag Chowdhuri
Devon Christman
Hye-eun Chu
Heidi Cian
Dante Cisterna
Ted Clark
Michael Clough
Scott Cohen
Ryan Coker
Mandi Collins
Laura Conner
Hannah Cooke
Peter Cormas
Brock Couch
Ginevra Courtade
Beth Covitt
Diana Crespo
Kent Crippen
Sugat Dabholkar
Zoubeida Dagher
Felisha Dake
Keren Dalyot
Kristy Daniel
Joe Dauer
Shannon Davidson
Elizabeth de los Santos
Lesley de Putter
Steph Dean
Cesar Delgado
Jacqueline DeLisi
Joe DeLuca
Maggie Demarse
Kadir Demir
Narendra Deshmukh
Desi
Clarissa Deverel-Rico
Andreia Dexheimer
Brayan Diaz
Rachel Dickler
İsmail Dönmez
Bat-Shahar Dorfman
Matheus dos Santos Barbosa da Silva
Remy Dou
Helen Douglass
Sara Dozier
Reynand Dumala-on
Benzegül Durak
Jale Ercan Dursun
Alper Durukan
Ben Van Dusen
Deborah Dutta
Justice Ejike
Heba EL-Deghaidy
Andrea Ellis
Uchenna Emenaha
Patrick Enderle
Megan Ennes
Robert Evans
Howard Everson
Gülüzar Eymur
Ayça Fackler
Zhenhan Fang
Sarah Fankhauser
Amy Farris
Shuo Feng
Daniela Fiedler
Vanessa Figueiredo
Francheska Figueroa
Caitlin Fine
Savanna Finley
Jonah Firestone
Matthias Fischer
Helen Fitzmaurice
Sarah Fogelman
Elizabeth Forde
Kelsie Fowler
Racheal Fredrick
Alyssa Freeman
Gunnar Friege
Gavin Fulmer
Matthew Gagea
Kristin Gagnier
Sara Gailey
Apostolia Galani
Alejandro Gallard
Jennifer Gallo-Fox
Grant Gardner
Amanda Garner
Deborah Garrity
Olasunkanmi A. Gbeleyi
İpek Pirpiroğlu Gencer
Frikkie George
Martha Georgiou
Saar Gershon
Emilie Gertz
Sarah Gilmore
Tamar Ginzburg
Jenna Gist
Christian Glandorf
Dana Gnesdilow
Anne Gold
Sebastian Gombert
Florencia Gomez Zaccarelli
María González-Howard
Tara Goodhue
Rachael Gordon
Amelia Gotwals
Savannah Graham
Adrian Grimm
frederick grinnell
Jorge Groß
Brenda Guerrero
Kristin Gunckel
Kristie Gutierrez
Candice Guy-Gaytán
Michael Guyot
Stefanie Habenicht
Sebastian Habig
Jonathan Hall
Linda Hämmerle
Sisi Han
Vicente Handa
Sari Harmoinen
Ute Harms
Tyler Harper-Gampp
Elizabeth Hasseler
Aaron Hauger
Christa Haverly
Kathryn Hayes
Cheng-Wen He
Mary Hedenstrom
Trevion Henderson
Sara Heredia
Ben Herman
Imogen Herrick
Hada Herring
Cari Herrmann Abell
Benedikt Heuckmann
Rebecca Hite
Benny Mart Hiwatig
Nthoesele Hlaela
Nancy Holincheck
Jacqueline Horgan
Xiao Huang
Mingchun Huang
Yuxi Huang
Malissa Hubbard
B Hug
Ally Hunter
Roberta Hunter
Lexi Hwang
Amal Ibourk
Bashirah Ibrahim
Mohammed Ibrahim
şahin idin
Robert Idsardi
Christopher Irwin
Paul Iwuanyanwu
Jennifer Jackson
Katie Wade-Jaimes
Marnie Jamieson
Benjamin Janney

Program Proposal Reviewers

Sophia Jeong
Yao JianXin
Qingna Jin
Loyiso Jita
Thuthukile Jita
Leonie Johann
Candi Johnson
Heather Johnson
M. Gail Jones
Thalía Juárez
Eugene Judson
Kostas Kampourakis
Ceren Baser Kanbak
Nam-Hwa Kang
Arya Karumanthra
Kate Kastelein
Jarod Kawasaki
Erdogan Kaya
Angela Kelly
Samia Khan
Cindy Khan-Jordan
Rola Khishfe
Meredith Kier
Flavia Kigozi
Heather Killen
Candice Kim
Won Jung Kim
Anna Kim
Kathryn Kirchgasler
Eric Kirk
James Kisiel
Tim Klavon
Inbal Klein-Avraham
Matthew Kloser
Tryna Knox
Mon-Lin Monica Ko
Shalece Kohnke
Lauri Kõlamets
Niki Koukoulidis
Kerstin Kremer
Olaf Krey
Sandhya Krishnan
Harini Krishnan
Christina Krist
Marcus Kubsch
Peter Lampert
Elon Langbeheim
Kathryn Lanouette
Corinne Lardy
Douglas Larkin
Heather Lavender
Katherine Lazenby
Thanh Le
Felicia Leammukda
Heather Leary
Elgin Leary
Judith Lederman
Dennis Lee
YewJin Lee
Samuel Lee
Gyeong-Geon Lee
Miechie Leowardy
Maleho Letloenyane
Daniel Matthew Levin
Sharona T Levy
Elizabeth Lewis
Fay Lewis
Shuangitng Li
Tingting Li
Erica Light
Lindsay Lightner
Sarah Lilly
Cynthia Lima
Jing Lin
Lucia Nthooa Lisene
Ms. Emily Little
Shiang-Yao Liu
Xingfeiyue Liu
Conghui Liu
Melissa Livingston
Luciana Lombardo
Victor Lopez
Christine Lotter
Vanessa Louis
Benjamin R. Lowell
Douglas Lownsbery
Yu-Ling Lu
Krista L Lucas
Julie Luft
Nick Lux
Edward Lyon
Aihanh Maasen
Anna MacPherson
Lauren Madden
Lene Møller Madsen
Tafirenyika Mafugu
Nicolette Maggiore
Daniela Mahler
Hamza Malik
Rie Malm
Danielle Malone
Lintle Maraisane
Jonathan Margolin
Mayra Marquez-Mendez
Stefanie Marshall
G. R. Marvez
Ruth Mathenge
Maria Rivera Maulucci
Evangelia Mavrikaki
Ebonee Maxey
Katherine McCance
Jonathan McCausland
Jessica McClain
Katie McCorrison
Kevin McElhaney
Christine McGrail
Thomas McKenna
Gozde McLaughlin
Liz McMillan
Sinead Meehan
Carolina Mehaffy
Smriti Mehta
Melissa Mendenhall
Karina Mendez Perez
Deepika Menon
Adjoa Mensah
Felicia Mensah
Denis Messig
Allison Metcalf
André Meyer
Carlos Meza-Torres
Malte Michelsen
Maizie Miller
Britt Miller
Brian Miller
James Minogue
Glen Mirabete
Collins Moga
Izzah Mardhiya Mohammad Isa
Lindsey Mohan
Rob Monahan
Smirla Ramos Montañez
Austin Moore
Kate Moore
Sierra Morandi
Patricia Moreira Seguel
Linda Morell
Amanda Joy Morrison
Terrell Morton
Emmanuel Moses
M Muchson
Ali Muller
Mika Munakata
Jaclyn Murray
Esther Kataate Namakula
Sharfun Islam Nancy
Josie Nardo
Yakhoub Ndiaye
Rauno Neito
Eva Nelson
Alana Newell
Argyris Nipyrakis
Ryan Nixon
Tara Nkrumah
Samanthia Noble
Eric Nolan
Mohd Syafiq Aiman Mat Noor
Jeffrey Nordine
Sadie Norwick
Noushin Nouri
Matthew Nyaaba
James Nyachwaya
John O'Meara
Oluwatobi Odeleye
Ella Ofek-Geva
Justina Ogodo
Taiwo Ogundapo
Ozlem Akcil Okan
Peter Okebukola
Adekunle Oladejo
Stacy Olitsky
Yann Shiou Ong
Franklin Onowugbeda
Jonathan Osborne
Kristina Otero
Peter Oyewole
Amy Padolf
Priyanka Parekh
Wonyong Park
Soonhye Park
Meredith Park Rogers
Michelle Parslow
Maya Shivani Patel
Scott Pattison
Kelli Paul
Chris Pavlovich
Melissa Pearcy
Mandy Peel
Hendrik Peeters
Sharon Pelech
Robyn Pennella
William Penuel
David Perl-Nussbaum
Beatriz Perret
Esther Peter
Verena Petermann

Program Proposal Reviewers

Lacey Peters
Erin Peters-Burton
Itumeleng Phage
Jaai Phatak
Andrea Phillips
Yuri Piedrahita
Takeshia Pierre
Ashlyn Pierson
Arianna Pikus
Daniel Pimentel
Fredyrose Ivan Pinar
Julia Plummer
Sarah Poor
Wardell Powell
Tharuesean Prasoplarb
LindaPreminger
Adepeju Prince
Rajashri Priyadarshini
Anna Pshenichny-Mamo
Muhammad Purwanto
Senay Purzer
Nathan Quarderer
Arif Rachmatullah
Jeffrey Radloff
Andrea Ragonese
Sarah Ragoub
Shukufe Rahman
Andrea Ramirez-Salgado
Ross Ramsey
Shelley Rap
Abdul Rauf
Rebecca Rawson
Jessica Reaves
Carina Rebello
Emma Refvem
Bianca Reinisch
Michael Reiss
Ren Rende
Matt Reynolds
Danielle Rhemer
Jennifer Richards
Gail Richmond
Rashida Robinson
Theresa Robinson
Gillian Roehrig
William Romine
Triin Rosin
Roslinawati Roslan
Pooja Roy
Veronika Rozhenkova
Rachel Ruggirello
Xana Sá-Pinto
Maryam Saberi
Marc Sager
Sriparna Saha
Adam Sahin
Emine Sahin
Ercin Sahin
Hardimah Said
Merav Saini
Line Saint-Hilaire
David Santibáñez
Elizabeth Saville
Kathleen Schenkel
Elvira Schmidt
Anita Schuchardt
Melissa Schug
Renee´ Schwartz
Meredith Schwendemann
Quentin Sedlacek
Helin Semilarski
Ozden Sengul
Sam Severance
Neta Shaby
Devyn Shafer
Sheikh Ahmad Shah
Mohamed Shahat
Katheryn Shannon
Ajay Sharma
Meenakshi sharma
Katherine Sharp
Calli Shekell
Max Sherard
Soo Won Shim
Soo-Yean Shim
Mary Short
Ginger Shultz
Maria Simani
Amber Simpson
Khushbu Singh
Harleen Singh
Judyanto Sirait
Monica Sircar
Dimitri Smirnoff
Patrick Smith
Clara Smith
Cody Smith
Jeffrey Snowden
Stefan Sorge
J. Caleb Speirs
Natalya St Clair
Alex St. Louis
Rebecca Stanley
Nancy Staus
Florian Stern
Gal Stern
Matt Stewart
Marta R. Stoeckel
Annabel Stoler
Mikayla Strasser
Christian Georg Strippel
Rachel Stronach
Kathy Stynen
Henry Suárez
Jee Kyung Suh
Mai Lill Suhr
Ryan Summers
Gina Svarovsky
Sara Sweetman
Mutiara Syifa
Tatiane Russo-Tait
Hamideh Talafian
Frederick Talaue
Kristina Tank
Giulia Tasquier
Lezly Taylor
Janari Teessar
Gerald Tembrevilla
Èlia Tena
Jared Tenbrink
Gregory Thomas
Shane Thomas
Gry Thorsen
Jenny Tilsen
Preethi Titu
Roger Tobin
Ana-Maria Topliceanu
Hong Tran
Maiza Trigo
Jennifer Tripp
Peggy Trygstad
Paul Tschisgale
Yu-Jan Tseng
Maojen Tseng
Hsiao-Lin Tuan
Eli Tucker-Raymond
Grace Tukurah
Heidi Turcotte
Uchenna Ugwuoke
Bhaskar Upadhyay
Maya Usher
Anjar Putro Utomo
Cansu Başak Uygun
Katrin Vaino
Katherine Vela
Patricia E Venegas-Weber
Claudia Vergara
Camilo Vergara
Tina Vo
Steffen Wagner
Jennifer Walker
Yangchunxiao Wang
Carol Waters
Maryrose Weatherton
Matthew Weinstein
Holger Weitzel
Julianne Wenner
Jill Wertheim
Jeanna Wieselmann
Karrie Wikman
Jennifer Wilhelm
Mia Williams
Matthew Wilsey
Kerri Wingert
Stephen Witzig
Christopher Wojciechowski
Rachel Wolf
Sissy Wong
Nicole Wong
Steven Worker
Ti'Era Worsley
Jingyun Wu
Rongxiu Wu
Peter Wulff
Xin Xia
Xin Xia
Lin Xiang
Yong Xie
Shiyu Xu
Shulong Yan
Jie Yang
Sonia Yeasmin
Elanur Yilmaz Na
Ella Yonai
Hyesun You
Laura Zangori
Carla Zembal-Saul
yingzhi zhang
Molly Zhang
Yang Zhanng
FangFang Zhao
Qiu Zhong
Li Zhu
Lynne Zummo
Melissa Zwick
Susan Zwiep

NARST Presidents

1928 **W. L. Eikenberry**
1929 **W. L. Eikenberry**
1930 **W. L. Eikenberry**
1931 **Elliot R. Downing**
1932 **Elliot R. Downing**
1933 **Francis D. Curtis**
1934 **Ralph K. Watkins**
1935 **Archer W. Hurd**
1936 **Gerald S. Craig**
1937 **Walter G. Whitman**
1938 **Hanor A. Webb**
1939 **John M. Mason**
1940 **Otis W. Caldwell**
1941 **Harry A. Carpenter**
1942 **G. P. Cahoon**
1943 **Florence G. Billig**
1944 **Florence G. Billig**
1945 **Florence G. Billig**
1946 **C. L. Thield**
1947 **Earl R. Glenn**
1948 **Ira C. Davis**
1949 **Joe Young West**
1950 **N. Eldred Bingham**
1951 **Betty Lockwood**
1952 **Betty Lockwood**
1953 **J. Darrell Barnard**
1954 **George G. Mallinson**
1955 **Kenneth E. Anderson**
1956 **W. C. Van Deventer**
1957 **Waldo W. Blanchet**
1958 **Nathan S. Washton**
1959 **Thomas P. Fraser**
1960 **Vaden W. Miles**
1961 **Clarence H. Boeck**
1962 **Herbert A. Smith**
1963 **Ellsworth S. Obourn**
1964 **Cyrus W. Barnes**
1965 **Frederic B. Dutton**
1966 **Milton P. Pella**
1967 **H. Craig Sipe**
1968 **John M. Mason**
1969 **Joseph D. Novak**
1970 **Willard D. Jacobson**
1971 **Paul D. Hurd**
1972 **Frank X. Sutman**
1973 **J. David Lockard**
1974 **Wayne W. Welch**
1975 **Robert E. Yager**
1976 **Ronald D. Anderson**
1977 **O. Roger Anderson**
1978 **Roger G. Olstad**
1979 **James R. Okey**
1980 **John W. Renner**
1981 **Stanley L. Helgeson**
1982 **Stanley L. Helgeson**
1983 **Carl F. Berger**
1984 **Ann C. Howe**
1985 **Ertle Thompson**
1986 **David P. Butts**
1987 **James P. Barufaldi**
1988 **Linda DeTure**
1989 **Patricia Blosser**
1990 **William G. Holliday**
1991 **Jane Butler Kahle**
1992 **Russell H. Yeany**
1993 **Emmett L. Wright**
1994 **Kenneth G. Tobin**
1995 **Dorothy L. Gabel**
1996 **Barry J. Fraser**
1997 **Thomas R. Koballa, Jr.**
1998 **Audrey B. Champagne**
1999 **Joseph S. Krajcik**
2000 **David F. Treagust**
2001 **Sandra K. Abell**
2002 **Norman G. Lederman**
2003 **Cheryl L. Mason**
2004 **Charles W. (Andy) Anderson**
2005 **John R. Staver**
2006 **James A. Shymanksy**
2007 **Jonathan F. Osborne**
2008 **Penny J. Gilmer**
2009 **Charlene M. Czerniak**
2010 **Richard A. Duschl**
2011 **Dana L. Zeidler**
2012 **J. Randy McGinnis**
2013 **Sharon J. Lynch**
2014 **Lynn A. Bryan**
2015 **Valarie L. Akerson**
2016 **Mary M. Atwater**
2017 **Mei-Hung Chiu**
2018 **Barbara Crawford**
2019 **Gail Richmond**
2020 **Tali Tal**
2021 **Eileen R. C. Parsons**
2022 **Renée Schwartz**
2023 **Gillian Roehrig**
2024 **Jomo Mutegi**
2025 **Jerome Shaw**

NARST Executive Directors

(NARST created the position of Executive Secretary in 1975; the title was changed to Executive Director in 2003)

1975–1980 **Paul Joslin**
1980–1985 **Bill Holliday**
1985–1990 **Glenn Markle**
1990–1995 **John Staver**
1995–2000 **Art White**
2000–2002 **David Haury**
2002–2007 **John Tillotson**
2007–2017 **Bill Kyle**
2018–2021 **Helen Schneider Lemay**
2021–Present **Lisa Martin-Hansen**

JRST Editors

1963–1966 **J. Stanley Marshall**

1966–1968 **H. Craig Sipe**

1969 **James T. Robinson**

1970–1974 **O. Roger Anderson**

1975–1979 **David P. Butts**

1980–1984 **James A. Shymansky**

1985–1989 **Russell H. Yeany, Jr.**

1990–1993 **Ronald G. Good**

1994–1999 **William C. Kyle, Jr.**

1999–2001 **Charles W. (Andy) Anderson** and **James J. Gallagher August**

2002–2005 **Dale R. Baker** and **Michael D. Piburn**

2006–2010 **J. Randy McGinnis** and **Angelo Collins**

2011–2015 **Joseph S. Krajcik** and **Angela Calabrese Barton**

2016–2020 **Fouad Abd-El-Khalick** and **Dana L. Zeidler**

2021–2025 **Felicia Moore Mensah** and **Troy Dow Sadler**

Emeritus Members

M. Agin
H. Andersen
C. Anderson
R. Anderson
C. Angell
D. Ash
D. Baker
N. Barnea
M. Barnes
G. Bartlett
J. Bencze
G. Berkheimer
L. Bethel
G. Bodner
J. Christopher
J. Clark
B. Crawford
H. Dahncke
O. De Jong
R. Dehaan
R. Doran
L. Enochs
E. Feher
U. Ganiel
R. Haney
H. Hanna
D. Haury
S. Helgeson
P. Hewson
A. Hofstein
J. Holbrook
W. Holliday
W. Jaffarian
P. Joslin
J. Kahle
D. Kennedy
G. Krockover
J. Lederman
J. Lemke
I. Lindauer
V. Lunetta
J. Mallinson
G. Markle
R. Mayes
M. McCarthy Hintz
A. McCormack
C. McFadden
G. Merzyn
J. Minstrell
M. Niaz
O. Norman
A. Nous
J. Novak
P. Okebukola
R. Olstad
M. Padilla
S. Pak
E. Parsons
G. Pedemonte
L. Phillips
M. Piburn
R. Poel
J. Poth
J. Prather
A. Qadeer
L. Rennie
D. Riechard
R. Rose
D. Schmidt
M. Sequeira
R. Sherwood
J. Shymansky
E. Simmons
D. Simonis
E. Smith
E. Sumfleth
J. Swift
H. Thier
M. Thier
A. Tiberghien
S. Tunnicliffe
E. Van Den Berg
R. Walding
W. Welch
R. Williams
L. Yore

NARST Award Recipients

2024 Distinguished Contributions to Science Education through Research Award

This award is presented at the Annual International Conference but is bestowed only when an outstanding candidate, or candidates, has been identified. It is given to recognize individuals who, through research over an extended period of time, have made outstanding and continuing contributions, provided notable leadership, and made a substantial impact in the area of science education.

Year	Awardee(s)
1986	**Anton E. Lawson**
1987	**Paul DeHart Hurd**
1988	**John W. Renner**
1989	**Willard Jacobson**
1990	**Joseph D. Novak**
1991	**Robert L. Shrigley**
1992	**Pinchas Tamir**
1993	**Jack Easley, Jr.**
1994	**Marcia C. Linn**
1995	**Wayne W. Welch**
1996	**Carl F. Berger**
1997	**Rosalind Driver**
1998	**James J. Gallagher**
1999	**Peter J. Fensham**
2000	**Jane Butler Kahle**
2001	**John K. Gilbert**
2002	**Audrey B. Champagne**
2003	**Barry J. Fraser**
2004	**Robert E. Yager** **Paul Black**
2005	**John C. Clement**
2006	**David Treagust**
2007	**Kenneth Tobin**
2008	**Dorothy Gabel**
2009	**Peter W. Hewson** **Leonie Jean Rennie** **Wolff-Michael Roth**
2010	**Reinders Duit** **Joseph Krajcik**
2011	**Norman Lederman**
2012	**Charles W. (Andy) Anderson** **Larry Yore**
2013	**Dale R. Baker**
2014	**Glen Alkenhead** **Richard Gunstone** **Frances Lawrenz**
2015	**Richard A. Duschl** **Meshach Mobolaji Ogunniyi**
2016	**Lynn D. Dierking** **John N. Falk** **Dana L. Zeidler**
2017	**Avi Hofstein**
2018	**Marissa Rollnick** **Jonathan Osborne**
2019	**Mary M. Atwater** **Maria Pilar Jiménez-Aleixandre**
2020	**Judy Dori** **Saouma Bou Jaoude**
2021	**Valarie Akerson** **Greg Kelly**
2022	**Fouad Abd-El-Khalick** **Gail Jones**
2023	**Franz X. Bogner** **Okhee Lee**
2024	**Dr. Angela Calabrese Barton** **Dr. Julie Luft**

NARST Award Recipients

Outstanding Doctoral Research Award

This award is given annually for the Doctoral Research judged to have the greatest significance in the field of science education from among all theses and dissertations nominated this year for the award.

Year	Awardee(s)	Advisor(s)
1992	Rene Stofflett	Dale R. Baker
1993	Julie Gess-Newsome	Norman G. Lederman
1994	Carolyn W. Keys	Burton E. Voss
1995	Jerome M. Shaw	Edward Haertel
1996	Christine M. Cunningham	William L. Carlsen
1997	Jane O. Larson	Ronald D. Anderson
1998	Kathleen Hogan	Bonnie K. Nastasi
1999	Fouad Abd-El-Khalick	Norman G. Lederman
2000	Danielle Joan Ford	Annemarie S. Palinscar
2001	Iris Tabak	Brian Reiser
2002	Mark Girod	David Wong
2003	Hsin-Kai Wu	Joseph Krajcik
2004	David L. Fortus	Ronald Marx Joseph Krajcik
2005	Thomas Tretter	Gail M. Jones
2006	Stacy Olitsky	Kenneth Tobin
2007	Julia Plummer	Joseph S. Krajcik
2008	Victor Sampson	Douglas Clark
2009	Lei Liu	Cindy E. Hmelo-Silver
2010	Heather Toomey	Phillip Bell Zimmerman
2011	Jeffrey J. Rozelle	Suzanne M. Wilson
2011	Catherine Eberbach	Kevin Crowley
2012	Melissa Braaten	Mark Windschitl
2013	Lori Fulton	Jian Wang
2014	Daniel Birmingham	Angela Calabrese Barton Anne-Lise Halvorsen
2015	Allison Godwin	Geoffrey Potvin
2016	Anna MacPherson	Jonathan Osborne
2017	Anita Schuchardt	Christian Schunn
2018	Katherine Wade-Jaimes	Renée Schwartz
2019	Anita S. Tseng	Jonathan F. Osborne
2020	Netta Shaby	Orit Ben Zvi-Assaraf
2021	Eben Witherspoon	Christian D. Schunn
2022	Won Jung Kim	Angela Calabrese Barton Alicia Alonzo
2023	Gary William Wright III	Cesar Delgado
2024	Grace P. Carroll K. "Ren" Rende Mendoza	Soonhye Park Carla Johnson

NARST Award Recipients

Early Career Research Award

The Early Career Research Award is given annually to the early researcher who demonstrates the greatest potential to make outstanding and continuing contributions to research in science education. The recipient will have received his/her Doctoral degree within five years of receiving the award.

Year	Awardee(s)
1993	Wolff-Michael Roth
1994	Deborah J. Tippins
1995	Nancy B. Songer
1996	Mary B. Nakhleh
1997	Peter C. Taylor
1998	J. Randy McGinnis
1999	Craig W. Bowen Gregory J. Kelly
2000	Angela Calabrese Barton
2001	Julie A. Bianchini
2002	Alan G. Harrison
2003	Fouad Abd-El-Khalick
2004	Grady J. Venville
2005	Randy L. Bell
2006	Heidi Carlone
2007	Bryan A. Brown
2008	Hsin-Kai Wu
2009	Troy D. Sadler
2010	Thomas Tretter
2011	Katherine L. McNeill
2012	Victor Sampson
2013	Alandeom W. Oliveira
2014	Cory Forbes
2015	Benjamin C. Herman
2016	Richard L. Lamb
2017	Ying-Chih Chen David Stroupe
2018	Doug Lombardi
2019	Hosun Kang Eve Manz
2020	Brian Donovan Dana Vedder Weiss
2021	Lama Jaber
2022	Maria González-Howard Laura Zangori
2023	Natalie S. King Christina Krist
2024	K.C. Busch Terrell R. Morton

NARST Fellows Award

The NARST Fellow Program is an award program that honors and recognize excellence in science education research and service. This program promotes and advances the NARST mission in science education, and the role of science education in the local and global community, by designating NARST members as Fellows.

Year	Awardee(s)
2021	Bryan A. Brown
2021	Richard A Duschl
2021	Gillian Roehrig
2022	Peter A. Okebukola
2023	Julie Bianchini
2023	Ron Blonder
2023	Patricia Friedrichsen
2024	Elizabeth Mavhunga
2024	Carla Zembal-Saul
2024	Renee' Schwartz
2024	Christina Schwarz
2024	Lynn Bryan

Excellence in Mentoring Award

Year	Awardee(s)
2024	Janet Carlson

Future NARST Meeting Dates

2025
March 22-25 | Washington, D.C.

2026
April 18-21 | Seattle, WA

2027
March 14-17 | Boston, MA

NARST Award Recipients

The *Journal of Research in Science Teaching (JRST)* Award

The *JRST* Award was awarded annually to the author or authors of the *Journal of Research in Science Teaching* article judged to be the most significant publication for the Volume year. It was awarded annually between 1974 and 2015.

Year	Awardee(s)
1974	Donald E. Riechard Robert C. Olson
1975	Mary Budd Rowe
1976	Marcia C. Linn Herbert C. Thier
1977	Anton E. Lawson Warren T. Wollman
1978	Dorothy L. Gabel J. Dudley Herron
1979	Janice K. Johnson Ann C. Howe
1980	John R. Staver* Dorothy L. Gabel* Linda R. DeTure
1981	William C. Kyle, Jr.
1982	Robert G. Good* Harold J. Fletcher* F. David Boulanger
1983	Jack A. Easley, Jr.
1984	Marcia C. Linn Cathy Clement Stephen Pulos
1985	Julie P. Sanford
1986	Anton E. Lawson
1987	Russell H. Yeany Kueh Chin Yap Michael J. Padilla
1988	Kenneth G. Tobin James J. Gallagher
1988	Robert D. Sherwood* Charles K. Kinzer* John D. Bransford* Jeffrey J. Franks* Anton E. Lawson*
1989	Glen S. Aikenhead
1990	Richard A. Duschl Emmett L. Wright
1991	E. P. Hart I. M. Robottom
1992	John R. Baird Peter J. Fensham Richard E. Gunstone Richard T. White
1993	Nancy R. Romance Michael R. Vitale
1994	E. David Wong
1995	Stephen P. Norris Linda M. Phillips
1996	David F. Jackson, Elizabeth C. Doster Lee Meadows Teresa Wood
1997	C. W. J. M. Klassen P. L. Linjse
1998	Julie Bianchini
1999	Phillip M. Sadler
2000	Allan G. Harrison J. Grayson David F. Treagust
2001	Fouad Abd-El-Khalick Norman G. Lederman
2002	Andrew Gibert Randy Yerrick
2003	Sofia Kesidou Jo Ellen Roseman
2004	Jonathan Osborne Sue Collins Mary Ratcliffe Robin Millar Richard Duschl
2005	Jonathan Osborne Sibel Erduran Shirley Simon
2006	Troy D. Sadler Dana L. Zeidler
2007	Jerome Pine Pamela Aschbacher Ellen Roth Melanie Jones Cameron McPhee Catherine Martin Scott Phelps Tara Kyle Brian Foley
2008	Christine Chin
2009	Kihyun Ryoo Bryan Brown
2010	Helen Patrick Panayota Mantzicopoulos Ala Samarapungavan
2011	Daphne Minner Jeanne Century Abigail Jurist Levy
2012	Julie A. Luft Jonah B. Firestone Sissy S. Wong Irasema Ortega Krista Adams Eun Jin Bang
2013	Edys S. Quellmalz Michael J. Timms Matt D. Silberglitt Barbara C. Buckley
2014	Joseph Taylor Susan Kowalski Christopher Wilson Stephen Getty Janet Carlson
2015	Matthew Kloser

*Tie

NARST Award Recipients

The NARST Outstanding Paper Award

The NARST Outstanding Paper Award was awarded annually for the paper or research report presented at the NARST Annual International Conference that was judged to have the greatest significance and potential in the field of science education. It was awarded annually between 1975 and 2015.

Year	Awardee(s)
1975	**John J. Koran**
1976	**Anton E. Lawson**
1977	***NO AWARD***
1978	**Rita Peterson**
1979	**Linda R. DeTure**
1980	**M. James Kozlow** **Arthur L. White**
1981	**William Capie** **Kenneth G. Tobin** **Margaret Boswell**
1982	**F. Gerald Dillashaw** **James R. Okey**
1983	**William C. Kyle, Jr.** **James A. Shymansky** **Jennifer Alport**
1984	**Darrell L. Fisher** **Barry J. Fraser**
1985	**Hanna J. Arzi*** **Ruth Ben-Zvi*** **Uri Ganiel*** **Russell H. Yeany** **Kueh Chin Yap** **Michael J. Padilla**
1986	**Barry J. Fraser*** **Herbert J. Walberg*** **Wayne W. Welch***
1987	**Robert D. Sherwood**
1988	**Barry J. Fraser** **Kenneth G. Tobin**
1989	**James J. Gallagher** **Armando Contreras**
1990	**Patricia L. Hauslein** **Ronald G. Good** **Catherine Cummins**
1991	**Nancy R. Romance** **Michael Vitale**
1992	**Patricia Heller** **Ronald Keith** **Scott Anderson**
1993	**Wolff-Michael Roth**
1994	**Wolff-Michael Roth** **Michael Bowen**
1995	**Wolff-Michael Roth**
1996	**Nancy J. Allen**
1997	***NO AWARD***
1998	**Wolff-Michael Roth** **Reinders Duit** **Michael Komorek** **Jens Wilbers**
1999	**Lynn A. Bryan**
2000	**Joseph L. Hoffman** **Joseph S. Krajcik**
2001	**Allan G. Harrison**
2002	**Carolyn Wallace Keys** **Eun-Mi Yang** **Brian Hand** **Liesl Hohenshell**
2003	**Wolff-Michael Roth**
2004	**Joanne K. Olson*** **Sharon J. Lynch*** **Joel Kuipers** **Curtis Pyke** **Michael Szesze**
2005	**Chi-Yan Tsui** **David Treagust**
2006	**Leema Kuhn** **Brian Reiser**
2007	**Eugene L. Chiappetta** **Tirupalavanam G. Ganesh** **Young H. Lee** **Marianne C. Phillips**
2008	**Guy Ashkenazi** **Lana Tockus-Rappoport**
2009	**Jrene Rahm**
2010	**Mark W. Winslow** **John R. Staver** **Lawrence C. Sharmann**
2011	**Matthew Kloser**
2012	**Shelly R. Rodriguez** **Julie Gess-Newsome**
2013	**Edward G. Lyon**
2014	**Ying-Chih Chen** **Soonhye Park** **Brian Hand**
2015	**Lori M. Ihrig** **Michael P. Clough** **Joanne K. Olson**

***Tie**

NARST Award Recipients

Outstanding Masters Thesis Award

This award was established in 1995 to be given annually for the Master's Thesis judged to have the greatest significance in the field of science education. It was last awarded in 2002.

Year	Awardee	Major Professor	Advisor
1995	Moreen K. Travis	Carol L. Stuessy	
1996	Lawrence T. Escalada	Dean A. Zollman	
1997	C. Theresa Forsythe	Jeffrey W. Bloom	
1998	Renee D. Boyce		Glenn Clark
1999	Andrew Gilbert		Randy K. Yerrick
2000	Rola Fouad Khishfe		Fouad Abd-El-Khalick
2002	Laura Elizabeth Slocum		Marcy Hamby Towns

Classroom Applications Award

The Classroom Applications Award was established in 1979. The award was given annually to authors whose papers were presented at the previous NARST Annual International Conference and judged to be outstanding in terms of emphasizing classroom application of research in science education. The award was last presented in 1991.

Year	Awardee(s)
1980 *Five Equal Awards*	Livingston S. Schneider John W. Renner
	Heidi Kass Allan Griffiths
	Ramona Saunders Russell H. Yeany
	Joe Long James R. Okey Russell H. Yeany
	M. James Kozlow Arthur L. White
1981 *Four Equal Awards*	Dorothy L. Gabel Robert D. Sherwood Larry G. Enochs
	Wayne Welch Ronald D. Anderson Harold Pratt
	Mary Ellen Quinn Carolyn Kessler
	P. Ann Miller Russell H. Yeany
1982 *Four Equal Awards*	Louise L. Gann Seymour Fowler
	Dorothy L. Gabel Robert D. Sherwood
	Thomas L. Russell
	Joseph C. Cotham
1983	Robert D. Sherwood Larry G. Enochs Dorothy L. Gabel
1984 *Three Equal Awards*	Mary Westerback Clemencia Gonzales Louis H. Primavera
	Kenneth G. Tobin Hanna J. Arzi Ruth Ben-Zvi Uri Ganiel
	Charles Porter Russell H. Yeany
1985 *Three Equal Awards*	Dan L. McKenzie Michael J. Padilla
	Margaret Walkosz Russell H. Yeany
	Kevin C. Wise James R. Okey
1986 *Four Equal Awards*	Sarath Chandran David F. Treagust Kenneth G. Tobin
	Darrell L. Fisher Barry J. Fraser
	Dorothy L. Gabel Stanley L. Helgeson Joseph D. Novak John Butzow V. K. Samuel
	Linda Cronin Meghan Tweist Michael J. Padilla
1987	Dorothy L. Gabel V. K. Samuel Stanley L. Helgeson Saundra McGuire Joseph D. Novak John Butzow
1988	Uri Zoller Ben Chaim
1989	James D. Ellis Paul J. Kuerbis
1990	Dale R. Baker Michael D. Piburn Dale S. Niederhauser
1991	David F. Jackson Billie Jean Edwards Carl F. Berger

NARST Standing Committees

Awards Committee

Final Year	Board Liaison
2025	**Amelia Wenk Gotwals** Michigan State University

Outstanding Doctoral Research Award

Final Year	Subcommittee Leadership
2024	**Julia Plummer** (Chair) Penn State University
2025	**David C. Owens** (Co-Chair) University of Montana
	Members
2024	**Jayma Koval** Georgia Tech University
2024	**Michal Zion** Bar Ilan University, Israel
2025	**Eunjin Bahng** Iowa State University
2025	**Maia Elkana** Washington University in St. Louis
2025	**Guopeng Fu** East China Normal University
2025	**Nilay Ozturk** Kirsehir Ahi Evran University
2025	**Annabel Stoler** Boston University
2026	**Mindy Chappell** Portland State University
2026	**Colby Tofel-Grehl** Utah State University
2026	**David Stroupe** Michigan State University
2026	**Dina Tsybulsky** Technion
2026	**Noemi Waight** University at Buffalo
2027	**Julianne Wenner** Clemson University

Early Career Research Award

Final Year	Subcommittee Leadership
2024	**Doug Larkin** (Chair) Montclair State University
2025	**Bridget Miller** (Co-Chair) University of South Carolina
	Members
2024	**Eleanor Abrahms** University of Massachusetts Lowell
2025	**Ben Herman** Texas A&M University
2025	**Christine Lotter** University of South Carolina
2025	**Erin Peters-Burton** George Mason University
2026	**Heidi Cian** Florida International University
2026	**Juan Diaz** Mount Aloysius College
2026	**Katherine Doerr** Malmo University, Sweden
2026	**Uchenna Emenaha** University of Texas at San Antonio
2026	**Laura Zangori** University of Missouri

NARST Standing Committees

Awards Committee (cont.)

Distinguished Contributions to Science Education Through Research

Final Year	Subcommittee Leadership
2024	**Xiufeng Liu** (Chair) University of Buffalo
2025	**Mei-Hung Chiu** (Co-Chair) National Taiwan University
	Members
2024	**Valarie Akerson** Indiana University
2024	**Dana Zeidler** University of South Florida
2025	**Mei-Hung Chiu** National Taiwan Normal University
2025	**Justin Dillon** Exeter University, UK
2025	**Kathy Trundle** Utah State University
2026	**Saouma BouJaoude** American University of Beirut, Lebanon
2026	**Carla Johnson** NC State University
2026	**Gail Jones** NC State University

NARST Fellow Award

Final Year	Subcommittee Leadership
2024	**Lama Jaber** (Chair) Florida State University
2025	**Enrique Suarez** (Co-Chair) University of Massachusetts, Amherst
	Members
2024	**Julie Luft** University of Georgia
2025	**Senay Purzer** Purdue University
2025	**Lezly Taylor** Virginia Polytechnic Institute and State University
2026	**Helena Aptyka** Institute for Biology Education
2026	**Laura B. Schneider** Great Mills High School

Elections Committee

Final Year	Representative from Ethics and Equity Committee
2025	**Regina McCurdy** Georgia Southern University
	Representative from the International Committee
2024	**Lucia Vazquez-Ben** Universidad da Coruña, Spain
	Committee Leadership
2025	**David Crowther** (Chair) University of Nevada, Reno
2026	**Nazan U. Bautista** (Co-Chair) Miami University
	Members
2024	**Holly Kennedy Amerman** University of Georgia
2024	**Miri Barak** Technion
2024	**Hernán Cofré Mardones** Pontificia Universidad Católica de Valparaíso, Chile
2025	**Carina Rebello** Purdue University-Main Campus
2026	**Angela Chapman** University of Texas Rio Grande Valley
2026	**Tim Klavon** Black Hills State University
	Board Member Liaison
2024	**Scott McDonald** Penn State University

NARST Standing Committees

Equity and Ethics Committee

Final Year	Committee Leadership
2025	**Justice T. Walker** (Chair) University of Texas at El Paso
2025	**Regina McCurdy** (Co-Chair) Georgia Southern University
	Members
2024	**Phillip Boda** University of California, Berkeley
2024	**Ebru Eren** Trinity College of Dublin, Ireland
2024	**Erdogan Kaya** George Mason University
2024	**David Steele** Alder Graduate School of Education
2025	**Marsha E Simon** University of West Georgia
2026	**Iliana De La Cruz** Texas A&M University
2026	**ReAnna Roby** Vanderbilt University
	Board Member Liaison
2025	**Sharon Nelson-Barber** WestEd

External Policy and Relations Committee

Final Year	Committee Leadership
2024	**Durdane Bayram-Jacobs** (Chair) Eindhoven University of Technology
2025	**Ellen Granger** (Co-Chair) Florida State University
	Members
2024	**Andy Cavagnetto** Washington State University
2024	**Xavier Fazio** Brock University, Canada
2024	**Francesca Williamson** Butler University
2025	**Sara Raven** Texas A&M University
2026	**Christina Baze** The University of Texas at Austin
2026	**Brittany Gavrin Hudson** University of Mary Washington
2026	**Mark Meszaros** Carolina Biological Supply Company
	Board Liaison
2024	**Senay Purzer** Purdue University

Graduate Student Committee

The Graduate Student Committee is composed of graduate student members appointed by the President-elect. The committee is chaired by the Graduate Student Representative, a non-voting (ex-officio) liaison to the NARST Board. A Board Director is appointed to serve as an ex officio advisor to the committee.

Final Year	Graduate Student Coordinator
2026	**Jennifer Bateman** (Chair) Clemson University
	Committee Leadership
2024	**Ti'Era Worsley** (Co-Chair) University of North Carolina -Greensboro
	Members
2024	**Justin Andersson** University of Nebraska-Lincoln
2024	**Sabrina Stanley** University of Alabama
2024	**Jared TenBrink** University of Michigan-Ann Arbor
2024	**Zhongyan Zhang** University of Leeds
2025	**Deborah Cotta** Universidad Federal de Minas Gerais, Brasil
2025	**Savannah Graham** Texas Christian University
2025	**Beyza Okan** Bogazici University
2025	**Amy Padolf** Florida International University
2025	**Mutiara Syifa** The Ohio State University
2025	**Johan Tabora** University of Illinois at Chicago

NARST Standing Committees

International Committee

Final Year	International Coordinator
2025	**Mercy Ogunsola-Bandele** (Chair) National Open University of Nigeria
	Committee Leadership
2024	**Hayat Hokayem** (Co-Chair) Texas Christian University
2025	**Ranu Roy** (Co-Chair) Amity University Kolkata, India
	Members
2024	**Lucía Vázquez Ben** Universidad da Coruña (Spain).
2024	**Irene Drymiotou** University of Cyprus and University of Groningen
2024	**Lee Kenneth Jones** Texas Tech University
2024	**Stefan Sorge** IPN Leibniz Institute for Science and Mathematics Education, Germany
2024	**Claudia Vergara** Alberto Hurtado University, Chile
2025	**Nuri Balta** Suleyman Demirel University
2025	**Aerin W. Benavides** University of North Carolina Greensboro
2025	**Jose Pavez** University of Georgia
2025	**Imran Tufail** University of Waikato
2026	**Estelle Blanquet** University of Bordeaux - France
2026	**Arif Rachmatullah** SRI International

Membership Committee

Final Year	Committee Leadership
2025	**Mihwa Park** (Chair) Texas Tech University
2025	**Melanie Linskey** (Co-Chair) Sam Houston State University
2026	**Joi Merritt** (Co-Chair) James Madison University
	Members
2024	**Robert Bennett** Georgia State University
2024	**Tugba Yuksel** Recep Tayyip Erdogan University
2025	**Harini Krishnan** Florida State University
2025	**Melanie Linskey** Sam Houston State University
2025	**Harleen Singh** University of Georgia
2026	**Jonathan Bowers** Michigan State University
2026	**Grant Gardner** Middle Tennessee State University
	Board Liaison
2026	**S. Selcen Guzey** Purdue University

NARST Standing Committees

Program Committee	
Final Year	**Committee Leadership**
2024	**Jomo Mutegi** (Chair) Old Dominion University
2025	**Jerome Shaw** (Co-Chair) University of California, Santa Cruz
	Members
2024	**Julie Bianchini** University of California, Santa Barbara
2024	**Tejaswini Dalvi** Univerity of Massachusetts, Boston
2024	**Amal Ibourk** Florida State University
2024	**Karl Jung** University of South Florida
2024	**Kathryn Kirchgasler** University of Wisconsin-Madison
2024	**Richard Lamb** East Carolina University
2024	**Felicia Leammukda** St. Cloud State University
2024	**Elizabeth Lewis** University of Nebraska-Lincoln
2024	**Patricia Patrick** Columbus State University
2024	**Jacob Pleasants** Oklahoma University
2024	**Wardell A. Powell** Framingham State University
2024	**Anita Schuchardt** University of Minnesota
2024	**Neta Shaby** Ben Gurion University of the Negev
2024	**Xiaoming Zhai** University of Georgia
2025	**Allison Antink-Meyer** Illinois State University
2025	**Quentin Biddy** University of Colorado
2025	**Narendra Dadarao Deshmukh** Homi Bhabha Centre for Science Education
2025	**Daniela Fiedler** Leibniz Institute for S&M Education
2025	**Peng He** Michigan State University
2025	**Sophia Jeong** University of Georgia
2025	**Anne Emerson Leak** University of California, Santa Barbara
2025	**Jing Lin** Beijing Normal University
2025	**Jamie N. Mikeska** ETS
2025	**Emily Adah Miller** University of Georgia
2025	**Tara Nkrumah** Arizona State University
2025	**Rebecca Swanson** University of Nebraska-Lincoln
2025	**Preethi Titu** Kennesaw State University
2025	**Yang Yang** Qingdao University

NARST Standing Committees

Publications Advisory Committee

Final Year	Committee Leadership
2024	**Lindsay Lightner** (Chair) Washington State University Tri-Cities
2025	**Tina Vo** (Co-Chair) University of Nevada, Las Vegas
	Members
2024	**Jana Bouwma-Gearhart** Oregon State University
2024	**Kent Crippen** University of Florida
2024	**Emily Dare** Florida International University
2024	**Hui Jin** Educational Testing Service
2024	**Carla Johnson** North Carolina State University
2025	**Cesar Delgado** North Carolina State University
2025	**Li Ke** University of North Carolina Chapel Hill
2025	**Linda Morell** UC Berkeley
2026	**Mohammad Azzam** Western University
2026	**Midhat Noor Kiyani** McGill University
2026	**Eli Tucker-Raymond** Boston University
	Board Liaison
2026	**Shiang-Yao Liu** National Taiwan Normal University

Research Committee

Final Year	Committee Leadership
2024	**Natalie King** (Chair) Natalie King
2025	**Bryan H. Nichols** (Co-Chair) Florida Atlantic University
	Members
2024	**Jana Bouwma-Gearhart** Oregon State University
2024	**Jessica Karch** Tufts University
2024	**Mi'Kayla Newell** Georgia State University (Grad Student)
2024	**Peter Wulff** University of Potsdam, Germany
2025	**Liam Guilfoyle** University of Oxford
2025	**James Nyachwaya** North Dakota State University
2025	**Mina Sedaghatjou** Rowan University
2025	**Karen Woodruff** Kean University
2025	**Ezgi Yesilyurt** Weber State University
2026	**Alexander Bohn** Northern Virginia Community College
2026	**Saramma Chandy** Mumbai University
2026	**Michael Giamellaro** Oregon State University
2026	**Colby Tofel-Grehl** Utah State University
2026	**Carrie-Anne Sherwood** Southern Connecticut State University
2026	**Stephen B. Witzig** University of Massachusetts Dartmouth
	Board Liaison
2024	**Malcolm Butler** University of North Carolina, Charlotte

NARST Standing Committees

Social Media, Website and Communications Committee	
Final Year	**Committee Leadership**
2025	**Ryan Cain** (Chair) Weber State University
2026	**Gary Weiser** (Co-Chair) Teacher College, Columbia University
	Members
2024	**Stanton Belford** University of Tennessee Southern
2024	**Amy Voss Farris** Penn State University
2024	**Mark Newton** East Carolina University
2024	**Stephanie Teeter** North Carolina State University
2025	**Anna Maria Arias** Kennesaw State University
2025	**Sarah Frodsham** Oxford Brookes University
2025	**Won Jung Kim** Santa Clara University
2026	**Marti Canipe** Northern Arizona University
2026	**Suzanne Poole Patzelt** Montclair State University
2026	**Steven Worker** University of California, Agriculture and Natural Resources
	Board Liaison
2026	**Patrick Enderle** Georgia State University

Sponsorship Program for Graduate Student Memberships

NARST members gave generously to sponsor graduate student memberships this year through the Graduate Student Sponsorship Program initiative. This program was started in response to needs of our graduate student community. Because graduate students may sometimes obtain assistance from their universities to attend the NARST conference, their NARST membership is usually not covered. While $60 may not sound like a lot of money, to a graduate student on an extremely limited budget, $60 is a lot.

Aligned with NARST's commitment to support the graduate student community, through donations to the GSSP, NARST was able to offer partial or full financial assistance toward joining the organization.

Last year (2022), with the $1,200 donated since the start of the program, we were able to provide financial assistance (partial or full) to 26 graduate students to become NARST members.

NARST Recognizes and Thanks this Year's Graduate Student Sponsors:

Meg Blanchard
Kathryn Hayes
Lisa Martin-Hansen
Felicia Mensah
Jonathan Osborne
Brian Reiser
Christina Schwarz
Shannon Taylor
Brooke Whitworth

vosaic™

AI-Powered Video Platform for Research & Teacher Coaching

Claim Your FREE Trial

vosaic.com/register

What is Vosaic AI?

Vosaic AI is an innovative new tool that enhances teacher coaching and improves video analysis for academic research. It utilizes one of the most robust Large Language Models (LLMs) on the market to analyze videos and give time-stamped feedback based on custom prompts.

What are the benefits of Vosaic AI

INSTANT FEEDBACK

Vosaic AI analyzes video transcripts using a variety of pre-set or custom prompts, giving you immediate, time-stamped feedback you can use to adjust your practice in real time.

FAST ANALYSIS

Whether you want a general summary of a video or time-stamps of specific behaviors, Vosaic AI can provide both before you even hit "play."

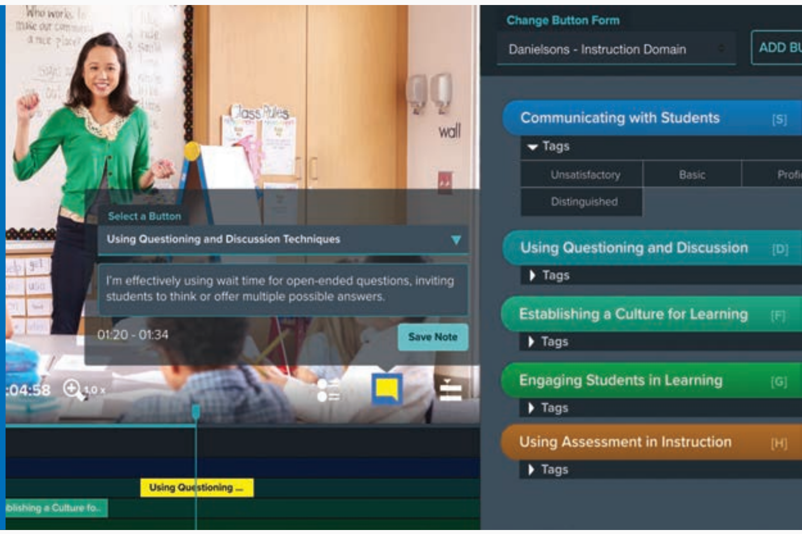
SUPER EASY TO USE

Vosaic AI follows the popular prompt-and-response pattern that many users are already familiar with from ChatGPT, Google, and other popular tools.

How it works?

Vosaic automatically transcribes videos and identifies different speakers—giving you an instant talk analysis.

From there, you can prompt Vosaic AI to give you feed-back by asking questions like, "Which domains of Dan-ielson's framework for teaching are used?" and Vosaic AI will respond with clickable time-stamped comments for you to review.



Beyond AI

Vosaic is the only cloud-based platform that helps you **code videos using moments with duration**, so you're only a click away from reviewing clips of practice and not just freeze frames with comments.

ADDITIONAL BENEFITS INCLUDE:

- ✓ Simple video recording & uploading
- ✓ Secure access & sharing
- ✓ Free user seats for blind coding
- ✓ Custom video coding
- ✓ Automated transcribing
- ✓ LMS integration (Canvas, Brightspace, etc.)
- ✓ IRR analysis and reporting
- ✓ World class support via chat, email, or phone

SPRINGER NATURE | SpringerOpen | palgrave macmillan

ADVANCING DISCOVERY

OA books at Springer Nature

Springer Nature publishes open access (OA) books and chapters under its SpringerOpen and Palgrave Macmillan imprints. We helped to pioneer OA book publishing, first piloting OA publication for books in 2011. We publish OA books across a wide range of areas in:

SCIENCE | TECHNOLOGY | MEDICINE | HUMANITIES & SOCIAL SCIENCES

550+ books

280+ chapters

200+ funding partners

Including:

European Commission, European Research Council, FWF, IEA, IMISCOE, Simula, The Wellcome Trust.

1,200+ leading authors and editors

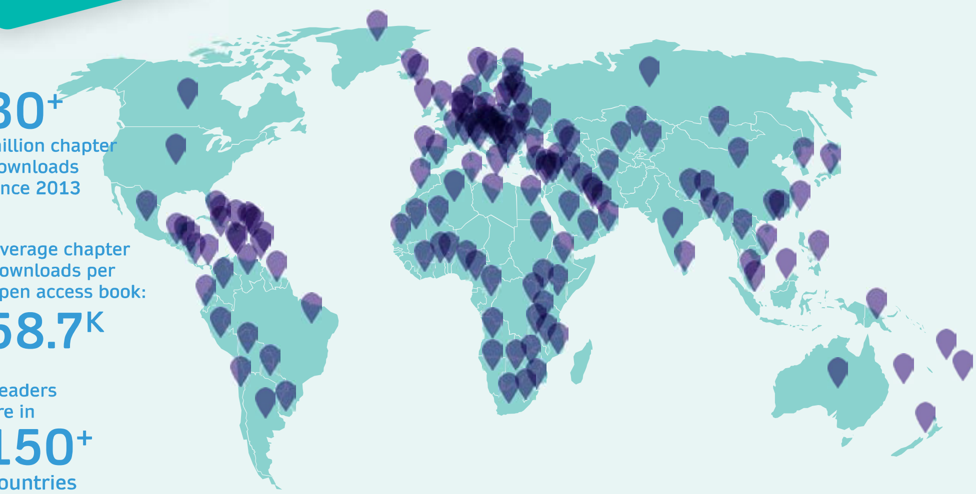
across **60+** countries

Downloads

30+ million chapter downloads since 2013

Average chapter downloads per open access book: **58.7K**

Readers are in **150+** countries



Benefits of publishing an OA book with Springer Nature

- Increased visibility
- Maximised discoverability
- Global readership
- CC BY 4.0 licence for maximum reuse
- Author retains copyright
- Rigorous peer review
- Access to Bookmetrix
- Free for readers (PDF, ePub, HTML, MOBI)
- Various formats accepted: monographs, edited volumes/collections, proceedings, protocols, short-form books (SpringerBriefs, Palgrave Pivots), chapters.

Contact Claudia Acuna
Editor, Science Education

claudia.acuna@springer.com

01KXI

NARST 2025 Conference Theme

Prepared by Jerome M. Shaw

In Praise of Science Teachers: Essential Partners in Researching, Reframing, and Reforming Science Learning

The year 2025 brings NARST's 98th Annual International Conference. With our 100th anniversary rapidly approaching, now is an opportune time to reflect on a critical component of our organizational identity: science teachers. Many of us recall the historical genesis of the acronym NARST as standing for the National Association for Research in Science Teaching. There is no science teaching without science teachers.

For this conference, let us centralize, emphasize, and praise the work science teachers do that enables and inspires our efforts as science education researchers. Inherent in this theme is an inclusive understanding of the terms science teaching, science teachers, and science education researchers. Science teaching is taken to include engineering education and the diverse ways in which we as humans engage in and contribute to both disciplines. Likewise, science teaching is not limited to formal brick-and-mortar or digital settings. In addition to professional educators, science teachers include parents, families, and other community members. Many of these same folks can and should play integral roles in the research process.

When we gather in the greater Washington, DC area, let us give voice to the myriad ways in which science teachers (writ large) contribute to researching, reframing, and reforming science teaching and learning. Bearing in mind throughout NARST's ultimate goal of helping all learners achieve science literacy.

Become a Graduate Student Sponsor!

If you didn't hear about the opportunity, or if you find that you can donate now, for just $60, you can pay the NARST membership of a graduate student.

To become a sponsor, please go to https://members.narst.org/donations/

NARST

A global organization for improving science education through research

98th Annual International Conference

March 22-25, 2025 | Washington, DC

In Praise of Science Teachers:

Essential Partners in **Researching**, **Reframing**, and **Reforming** Science Learning

OLD DOMINION UNIVERSITY

Darden College of Education and Professional Studies

FIND YOUR NEXT

Take your career to the next level and explore our rigorous graduate programs designed for working professionals. Join us as we combine research, education, and industry to push boundaries and reach new heights.

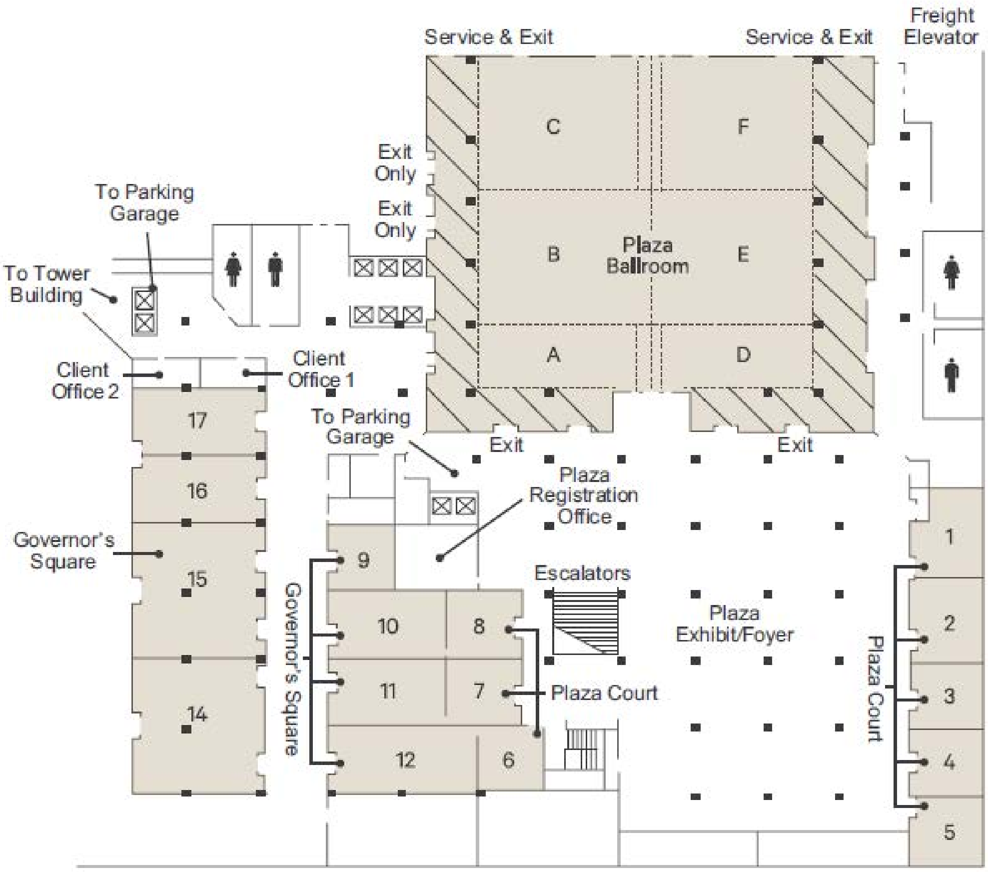
EXPLORE GRADUATE PROGRAM AREAS IN:

- Teaching & Educational Leadership
- Counseling & Human Services
- Tourism & Sport Sciences
- Workforce Development
- Learning & Information Sciences

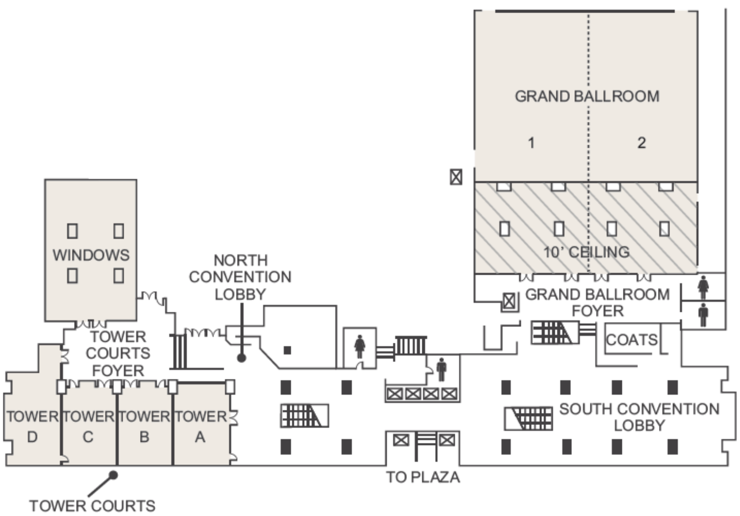
LEARN MORE:

757.683.6004 | DCEPSconnect@odu.edu | odu.edu/eps

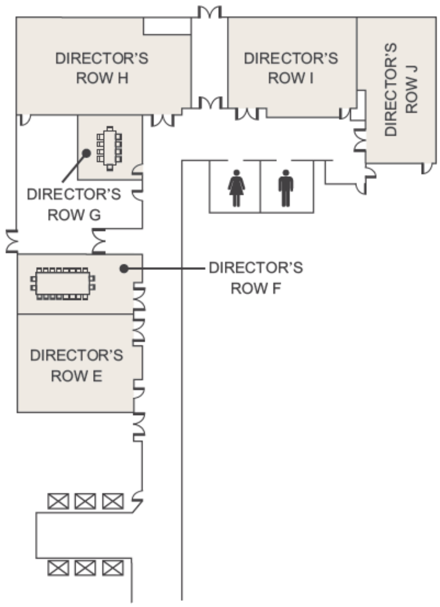
PLAZA BUILDING - CONCOURSE LEVEL



TOWER - SECOND FLOOR



DIRECTOR'S ROW



Lobby Level

8 MARCH 2024

Virtual Conference Day

Plenary Session
Presidential Welcome to the Virtual Conference Day
8-Mar-24, 7:00 AM-7:20 AM
Location: Zoom A

Social Event
Meet and Greet
8-Mar-24, 7:20 AM-7:40 AM
Location: Zoom A

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set
Developing Critically Caring Science Classrooms
8-Mar-24, 7:45 AM-8:45 AM
Location: Zoom A

"It Makes You Feel Like You've Actually Been, Like, Heard": Care in Collective Sensemaking
Jason Buell*, Northwestern University, USA
Yang Zhang, Northwestern University, USA
Chris Griesemer, University of California Davis, USA
Jessica Alzen, University of Colorado Boulder, USA
Kelsey Edwards, Northwestern University, USA
Cindy Passmore, University of California Davis, USA
William Penuel, University of Colorado Boulder, USA
Brian Reiser, Northwestern University, USA

ABSTRACT
Science classrooms have been making a shift from individual students learning about science to students working together to figure out the science. Creating classrooms where sensemaking is a collective enterprise means that sensemaking is a social achievement and not just an individual, cognitive one. Because of this, we see a need for additional research on the relational nature of sensemaking. In this paper, we describe an episode from a 7th grade science classroom . We illustrate ways that students are treating each other with care and then, ultimately, deepening their own sensemaking. We use this to illustrate one of the ways that care supports collective sensemaking through attending to the relational aspects of their community. If science classrooms are to continue shifts toward collective sensemaking, we argue that critical caring is a necessary component for classrooms.

A Systematic Review of Theories of Caring in Science Education

Christina Krist, University of Illinois Urbana-Champaign, USA
Enrique Suarez*, University of Massachusetts Amherst, USA

ABSTRACT

This paper investigates the use of care theories (e.g., ethic of care, critical care, and radical care) in science education. These theories challenge dominant educational paradigms by emphasizing relationships with students to foster growth and tackle inequities. However, despite their prevalence in broader education research, they remain largely absent from science education literature, potentially limiting the transformative potential of science learning for justice.Through a systematic review, we explored how care theories have been used in pre-K-12 science education research, their influence on teaching and learning approaches, and outcomes of care-focused interventions. We found a significant reliance on vague and underdeveloped discussions of care in science education, lacking robust frameworks. In addition, the findings underscore a divide between prioritizing care for the natural world versus human beings, neglecting care for peers within the local learning context. Finally, few articles designed interventions targeting caring practices, reflecting a tendency to view care as innate rather than teachable.The under-theorization of care in science education hampers its potential for supporting equity and justice. We call for more careful conceptualizations of care in science education that move beyond surface-level politeness to engage deeply with ethical dimensions of learning and knowledge-building.

Care and Risk in a Fifth-Grade Science Classroom

Annabel Stoler*, Boston University, USA
Eve Manz, Boston University, USA

ABSTRACT

This paper explores the way that care is enacted in a fifth-grade science classroom and how this care is connected to students' epistemic engagement with investigation and modeling. Science learning is inherently social, and therefore it is deeply relational work. We use frames analysis to understand how our partner teacher frames activities and discussions in her classroom during two units focused on modeling and investigation. We then explore how these framings are connected to the ways that the teacher and her students exhibit care toward each other and towards disciplinary ideas. Our findings highlight the tensions that teachers experience when attempting to simultaneously increase opportunities for children to engage with the practices of sciences and become epistemic agents as well as equitably attend to students' ideas with care.

"It's Difficult to Separate My Feelings": Exploring a Preservice Teacher's Wrestling with Relationality

Allison Metcalf*, Florida State University, USA
Lama Jaber, Florida State University, USA
Shannon Davidson, University of Alabama, USA

ABSTRACT
Critical self-reflection on positionalities and experiences is an essential part of preservice science teachers' (PSTs') learning and development of critically caring stances. Such critical reflection, however, is deeply complex and emotional work for PSTs. As teacher educators, we feel compelled to sit with and seek to understand this complexity. Toward this end, in this paper we center the voice and experiences of Carmen, a Black preservice teacher in a teacher preparation course who wrestles with tensions between her own racialized experiences and her ethical commitment to building authentic relationships with students. Using qualitative case study methods, we explore Carmen's wrestling in the course as she engages in critical self-reflection.

Multi-Strand Stand-Alone Paper Set 1
8-Mar-24, 7:45 AM-8:45 AM
Location: Zoom B

Strand 12: Technology for Teaching, Learning, and Research
A Theoretical Framework to Evaluate AI-Based Information Technologies for Critical Engagement With Science: A Proposition
Inbal Klein-Avraham*, Technion - Israel Institute of Technology, Israel
Esther Greussing*, Technische Universität Braunschweig, Germany
Monika Taddicken, Technische Universität Braunschweig, Germany
Ayelet Baram-Tsabari, Technion - Israel Institute of Technology, Israel

ABSTRACT
The introduction of ChatGPT and the following explosion in generative AI-based technologies redefine how learners and lay people can access and use science-related information. While scholarly efforts are increasing, we are missing a theoretical framework that will facilitate a consistent and cohesive scholarly discussion about recently available technologies and hegemonic ones as well. The proposed theoretical framework is designed for characterization, evaluations, and comparison of artificial intelligence (AI) based information technologies in the particular context of critical engagement with science. Hence, the framework is attentive to whether information technologies support critical engagement with science and bridge over low-level digital and science literacies. Hierarchically constructed, it observes first the technology – contemplating technological properties, user experience, and content presentation – and, secondly, the context in which the technology is being used. Each of these supplementing components combines multiple criteria that allow a holistic yet practical assessment of a large variety of AI-based information technologies. The framework contribution is more than providing a reflection aid and a theoretical base-line for scholarly efforts, it can also support practitioners in their understanding of AI-based information technologies, the implementation in the field, and better use and presentation of such technologies to learners.

Strand 11: Cultural, Social, and Gender Issues

Reframing Equitable Physics Education from the Lens of Marginalized Family: An Ethnographic Study

Izzah Mardhiya Mohammad Isa*, Universiti Teknologi Malaysia, Malaysia
Muhammad Abd Hadi Bunyamin, Universiti Teknologi Malaysia, Malaysia
Fatin Aliah Phang, Universiti Teknologi Malaysia, Malaysia

ABSTRACT

Funds of knowledge (FOK) studies are generally not commonly found in developing nations, especially Malaysia. This study aims to identify a marginalized rural student's FOK related to physics and explore how her parents shape those FOK at home. A single case ethnography study approach was adopted by conducting home visits and participant observation. A marginalized girl student (Grace, pseudonym) and her parents were the research participants. Data were transcribed and analyzed using the constant comparative method to generate themes. Grace holds significant cultural values in her life. Grace proposed that the Magunatip Dance is a comprehensive representation to describe physics. Grace's ethnicity as a Sino integrates her parents' role into one cultural system at home where agricultural economic life brings fortune to the family. Grace gained many skills to survive poverty. A woman like her needs to have masculine skills to do a home renovation, mini carpentry, painting, or even duty task for some reason. Grace's parent parenting styles (multicultural integration) are shaped by childhood experiences and epistemological ideas pertaining to the field of physics. Reframing physics education to focus more on students' life culture and spiritual feminism, especially in female students, is this study's contribution.

Strand 7: Pre-service Science Teacher Education

Effects of Opportunities to Learn on Pre-Service Science Teacher Knowledge and Beliefs

David Letloenyane*, University of the Free State, South Africa
Loyiso Jita, University of the Free State, South Africa

ABSTRACT

Teacher education programmes are used worldwide to prepare pre-service science teachers and while this is the norm, there is little evidence in the literature that suggest the nature of opportunities to learn that lead effective science teachers. This paper explores the effects of opportunities to learn in science teacher education on pre-service teacher knowledge and beliefs. This quantitative study used questionnaires to collect opportunities to learn, teacher knowledge and beliefs data from 112 science pre-service teachers from four universities in South Africa. The findings suggest that better opportunities to learn prevail in science teacher education when practicum experiences include integration of theory and practice, proper mentoring of science pre-service science teachers; and when the students are well-grounded in their subject specialisation. We therefore recommend consideration of these opportunities to learn in the (re)design of teacher education programmes because they may provide greater purchase in terms of science pre-service teacher learning.

Strand 8: In-service Science Teacher Education

Examining a Boundary-Spanning Case Study Within a School-University Partnership That Supports Science Teacher Professional Development

Maiza de Albuquerque Trigo*, University of Luxembourg, Luxembourg
Christina Siry, University of Luxembourg, Luxembourg
Thierry Frentz, Ministry of Education, Luxembourg

ABSTRACT

This contribution aims to present a case study of boundary-spanning within a school-university partnership focused on science teacher education. By looking into video recording of team meetings and the reflections of three boundary spanners, shifts in roles are identified and self-reflections emerges as acknowledgement of the spanning is explored. Grounded in sociocultural perspectives and using qualitative approaches, this contribution will present a participatory research example to build the case study. By analyzing the data, the team's collaborative structure (reflect-dialogue-act) is retraced and unfolded, and the boundary spanning emerges as a concept to be explored within the team dynamics.

Roundtable Discussions

8-Mar-24, 9:00 AM-10:00 AM
Location: Zoom A Breakout Rooms

Strand 11: Cultural, Social, and Gender Issues
Roundtable

Impostor Phenomenon and Belongingness Among Science Faculty: An Exploratory Study

Devasmita Chakraverty*, Indian Institute of Management Ahmedabad, India

ABSTRACT

Impostor phenomenon includes a psychological dissonance experienced by high-achieving, successful people when they consider their success to be erratic and due to luck rather than competence. Among faculty, impostor feelings are positively correlated with fear, self-doubt, anxiety, emotional exhaustion, personality trait, status of tenure, and the ability to pursue research and teaching. This US-based study examined the contributors to impostor phenomenon among faculty in science fields, that is not well documented. The study used a theory of professional identity development. Fifty-six one-on-one, semi-structured phone interviews (~30-45-minutes) were conducted. Data were qualitatively analyzed using constant comparison and analytic induction to construct themes. Participants were predominantly White and female. Contributors to impostor phenomenon related to both, research and teaching activities and included: peer comparison, evaluation, recognition, and perceived lack of competency. Even among faculty of different ranks and experience levels, antecedents of the impostor phenomenon were similar, characterized by a persistent fear of being found out as being incompetent or incapable. Professional development for PhD students or early career researchers need to be tailored to address competency development and improve belongingness through a support system, mentorship, role modelling, networking, and community building.

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

A Qualitative Exploration of Latina Professors' Impostor Phenomenon in STEM

Devasmita Chakraverty*, Indian Institute of Management Ahmedabad, India

ABSTRACT

Impostor phenomenon encompasses a distorted sense of self-evaluation; one fears intellectual fraudulence, attributing achievements to luck and underestimating one's ability. Impostor phenomenon among Latinx people in science focuses on poor mental health, minority status stress, burnout, lower self-efficacy, academic disengagement, and distress. Yet impostor experiences related to their ethnic identity are poorly documented. This US-based study used a theory of identity-based "othering" and qualitatively explored how 13 Latina professors describe their impostor phenomenon in science. Participants were selected through convenience/snowball sampling. One-on-one, semi-structured phone interviews (~30-45-minutes) were conducted. Data were analyzed using constant comparison and analytic induction to construct these themes: cultural aspects of being Latina, explicit or implicit messaging at work, mistreatment from colleagues, and mistreatment from students. Latina professors felt like impostors through "othering" and a lack of acknowledgment of faculty status. They felt isolated and tokenized as minorities at predominantly white institutions. They were questioned about their legitimacy as a scientist and struggled to find a community based on shared identity. Participants experienced lack of belonging and questioned if they entered their field through luck, minority status, and faking success. Tailored mentorship and professional development opportunities for future Latina/x professors could combat impostor feelings.

Strand 1: Science Learning: Development of student understanding
Work-in-progress Roundtable

Understanding Obstacles to Conceptualizing, Transforming, and Analyzing Multidimensional Datasets

A Lynn Stephens*, The Concord Consortium, USA
Natalya St. Clair, The Concord Consortium, USA
Daniel Damelin*, The Concord Consortium, USA

ABSTRACT

Using conventional data analysis tools to teach data science presumes a certain level of confidence with data tables. Additionally, much of the data available for classroom use is complex and has a multidimensional set of related variables. Standard spreadsheets may work well with students who are confident math learners and who can easily grasp the conventions of tabular data representations, but may leave behind those who learn better by doing or whose internal representations of data structure do not match conventional external representations. This exploratory study describes preliminary results from 13 semi-structured think-aloud interviews of high school students, looking at how students conceptualize multidimensional datasets. The interviews indicate that the nature of the tasks given to students for analyzing the data had a strong influence on how they talked about

data structure (if at all). These findings have unexpected resonance with preliminary results from a companion study (authors, in progress) where experts described options for dataset structure according to what question was to be asked of those data.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Work-in-progress Roundtable

The Emotional Impact of Science Textbook Images: Creating an Affective Science Image Dataset

Isabella DeRegis*, Towson University, USA
Brian Miller, Towson University, USA

ABSTRACT

A key aspect of all science textbooks is the images that are spread throughout. Images are meant to convey information, but also, they have a powerful way of provoking emotions in the viewer. Research on the emotional impact of science images derived from science textbooks is not prevalent partly because there are few existing research tools. Therefore, our main objective is to create an affective image dataset to aid researchers, including ourselves, to further advance in this area. In this work in progress, [authors] have collected a dataset of six hundred scientific images that will be uploaded on Amazon's Mechanical Turk to be rated by individuals for their valence and arousal. With these results, we will analyze the images' characteristics and also train artificial intelligence to judge the emotionality of other science images.

Strand 14: Environmental Education and Sustainability
Work-in-progress Roundtable

Engaging in Socioscientific Issues with Scientists' Disagreement: The Case of Nuclear Wastewater Release Controversy

Won Jung Kim*, Santa Clara University, USA
Junhwan Ahn*, Santa Clara High School, USA

ABSTRACT

This paper, as an ongoing work-in-progress, explores how the socioscientific reasoning that involves epistemic practices of science and risk assessment can help citizens, particularly students and educators, tackle socioscientific issues (SSI) presenting significant experts' disagreement. One example of such challenging SSIs is the controversy over the Fukushima nuclear waste water release into the Pacific Ocean, about which scientists and experts have not yet reached an agreement about the safety of release and its consequential risks. We elaborate on competing claims in this issue and varying evidence, reasoning, and perspectives presented in the claims. We conduct an exploratory content analysis of the statements of scientists, experts, and different stakeholders, those present in publicly available digital news articles. Using a comparative constant analysis, we identify 5 categories of claims (policy-procedure, perspective-taking, justice consideration, risk assessment, and scientific justification) falling under two perspectives (pro-release and release-skeptical). Drawing on a further reflexive thematic analysis of the 'risk assessment' and 'scientific justification' claims in reference to the Grasp of Evidence framework, we identify evidentiary reasoning dimensions that help us figure out the areas of disagreement and agreement among the pro-release and release-skeptical claims. We discuss the implication of these findings for SSI-informed science instructions.

Strand 14: Environmental Education and Sustainability
Roundtable

High School Science Students' Visions of Mobilization of Their TechnoSocial Values

J. Lawrence Bencze*, OISE, University of Toronto, Canada
Dave Del Gobbo, Peel District School Board, Canada
Majd Zouda, OISE, University of Toronto, Canada
Sarah El Halwany, Université de l'Ontario français, Canada
Sheliza Khan, University of Toronto, Canada
Gonzalo Guerrero, IOE, University College London, United Kingdom

ABSTRACT
'STEM' (science, technology, engineering and mathematics) education initiatives are very influential. They often, however, prioritize selection of potential STEM workers while compromising literacy of others. In promotion of engineering design, for instance, they tend to omit or sanitize adverse effects of technologies on (a)biotic things (e.g., climate crises) that appear associated with influences of powerful people (e.g., financiers) and groups (e.g., governments, corporations & transnational groups) on STEM fields and much more. As reported here, however, through application-based instruction (vs. inquiry-based learning), most 10th-grade school science students seemed able to design and implement functional technologies that also prioritized social justice and environmental vitality outcomes. Moreover, apparently due to the teacher's direct applied instruction about 'sociotechnical imaginaries' (i.e., values, principles, etc. guiding assemblage of (a)biotic and semiotic actants into a supportive network), many students proposed networks of actants—particularly in African contexts, drawing from earlier teacher modelling—that supported values, such as environmental sustainable and fair labour agreements, that they considered inherent to their newly-developed technologies. Consequently, students' ontological, epistemological and axiological positions seemed changed. Among factors influencing outcomes, local curricula, the teacher's beliefs and the teacher's creativity with direct teaching of sociotechnical imaginaries seemed very helpful.

Multi-Strand Stand-Alone Paper Set 2

8-Mar-24, 9:00 AM-10:00 AM
Location: Zoom B

Strand 8: In-service Science Teacher Education

Physics Teachers' Belief System: Beliefs of Knowledge, Teaching, Learning, and Science

Ozden Sengul*, Bogazici University, Turkey

ABSTRACT
This study aims to examine physics teachers' beliefs about knowledge, science, teaching and learning science to understand the relationship among four belief systems. Participants were 32 high school physics teachers, who were interviewed once through a semi-structured interview protocol. The interviews were transcribed and analyzed through constant comparative method to categorize teachers' beliefs in different levels: traditional, transitional, and constructivist and quantify the nominal data for descriptive and correlational statistics. The results indicated that teachers mostly held transitional beliefs about knowledge and science while their beliefs were constructivist on teaching and learning science. Although there was a significant relationship between beliefs about knowledge and science as core beliefs and between beliefs about teaching and learning science as peripheral beliefs, no significant correlation was found between core and peripheral beliefs. These findings offer a report as a guide to address teachers' beliefs through the design of future professional development programs.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Factors Affecting Science Academic Achievement among ESLs:A Meta-Synthesis of the Literature

Thalia Juarez*, University of Texas Rio Grande Valley, USA
Brian Gabrysch*, University of Texas Rio Grande Valley, USA

ABSTRACT
This meta-synthesis analysis examines qualitative literature from nine articles investigating the factors influencing science academic achievement among English as a Second Language (ESL) students. The analysis employs a systematic approach to identify common themes and patterns across the selected qualitative studies. Through a rigorous literature search and data extraction, the study synthesizes qualitative data from diverse contexts and populations of ESL students. The factors affecting science academic achievement are explored within the framework of ecological systems theory, allowing for a multilevel analysis of microsystem, mesosystem, exosystem, and macrosystem influences. The meta-synthesis reveals several recurring factors identified into six categories. These include: 1) teaching approaches and teachers' expertise, 2) language, 3) institutionalized context, 4) student's identity, 5) socioeconomic status, and 6) life experiences outside the classroom. The analysis highlights the interconnectedness of these factors and their combined influence on ESLs' science academic achievement. The implications of the findings for educators and policymakers are discussed, emphasizing the need for culturally responsive pedagogy and collaborative efforts to create inclusive science learning environments. This meta-synthesis contributes to a deeper understanding of the complexities surrounding ESL students' science education and offers insights to enhance their academic success and engagement in science learning.

Strand 6: Science Learning in Informal Contexts

Bringing Middle School Students and Scientist Together: Perceived Value of Science Communication Meetings

Melike Hanedar, Bogazici University, Turkey

Ipek Paksoy, Bogazici University, Turkey
Gaye Ceyhan*, Bogazici University, Turkey

ABSTRACT
In today's era, characterized by the prevalence of misinformation and disinformation, as well as the rejection of established scientific facts, the importance of effective science communication has been emphasized. This has been particularly evident during the recent global pandemic, underscoring the need for a dialogical approach to science communication that facilitates public interaction with scientific information and promotes the cultivation of positive attitudes toward science. This study was conducted to facilitate science attitudes by bringing eighty seventh-grade students with scientists through five science communication meetings regarding the middle school science topics. The extent to which middle school students found the science communication experience useful, important, and interesting was investigated in the context of expectancy-value theory. Results indicated a progressive increase in the utility, attainment, and intrinsic value which students associated with the science communication meetings following each session. This research provides important insights into the current body of knowledge regarding the powerful role of science communication within the framework of expectancy-value theory. Additionally, it offers guidance to educators and researchers in designing productive science communication sessions, thereby enhancing the existing literature in this area.

Strand 8: In-service Science Teacher Education

Supporting Science Teachers in the Design and Enactment of Socioscientific Issues and Model-Based Learning

Benzegul Durak*, Düzce University, Turkey
Mustafa Topçu*, Yildiz Technical University, Turkey

ABSTRACT
This study proposes a three-phased professional development (PD) program for middle school science teachers and examines their PD on Socioscientific Issues and Model-Based Learning (SIMBL) framework. The three phases were learning with SIMBL, teaching with SIMBL, and curriculum unit design with SIMBL. Three middle school science teachers from different public and private schools completed the study. This is a multiple case study and the data sources were three interviews before and after the PD program, and after the class implementation. The data were analyzed using the Interconnected Model of Professional Growth framework to explore the teachers' enactment of SIMBL units, their interactions with the researchers and colleagues during PD program, their beliefs about teaching and learning, and their perception of the outcomes of SIMBL units. As a result, teachers were classified as competent, diligent, and naïve, and findings show that the practices of teachers were positively affected by their frequent interaction and reflection on the received feedback regarding their unit plans and classroom practices. Lastly, the SIMBL framework makes SSI teaching more accessible and effective by integrating MbL practices for teachers and students.

Poster Session
8-Mar-24, 10:15 AM-11:15 AM
Location: Zoom A Breakout Rooms

Colorado Science Education Research

Reliability Analysis of Psychological Measures related to STEM Persistence in Undergraduate Students

Rena Kirkland*, Adams State University, USA
Aaron Montoya, Adams State University, USA
Marlene Garcia Araiza, Adams State University, USA

ABSTRACT

Research suggests that psychological factors are related to science, technology, engineering, and mathematics (STEM) persistence especially for underrepresented students; however, most psychological instruments have been validated with traditional students. In the current study, we report reliability estimates for measures of science identity, science motivation, and science self-efficacy with a sample of undergraduate college students from a Hispanic Serving Institution (N=309). Internal consistency and test-retest reliability was estimated with Cronbach's alpha and intra-class correlation coefficient respectively. We report Cronbach alpha values separately for male (N=152), female (N=152), Hispanic (N=111), and White (N=115) students. We also examined whether there were statistically significant differences in the alpha values between these groups. Results demonstrated good to excellent reliability estimates for internal consistency and test-retest reliability for all groups. We conclude by emphasizing the importance that science educations researchers examine, report, and interpret reliability estimates for their measures for each dataset.

Strand 11: Cultural, Social, and Gender Issues

School-Level Earth Science Enrollment as a Mediator of Demographic Predictors of Earth Science Performance

Christine Schlendorf*, Farmingdale State College, USA
Angela Kelly, Stony Brook University, USA
Robert Krakehl, Stony Brook University, USA

ABSTRACT

Student participation and performance in high school Earth science coursework is an important factor in lifelong scientific literacy and workforce readiness in geoscience fields. Many studies have shown that high school students have not experienced equitable and uniform access to Earth science education. This study explored secondary Earth science coursework access and performance in New York State, where 70% of students take an Earth science course before graduation. A non-experimental, correlational research design was used to explore school-level variables (locale, ethnicity, socioeconomic status, and English language proficiency) and their relationship to students' Earth science participation and performance. The sample included N=1176 public schools, N=2457 Earth science teachers, and N=153,749 Earth science students in New York State during the 2016-17 academic year. Data

revealed that Earth science performance was positively predicted by the prevalence of Earth science participation in the school and demographic variables, with small to medium effects. However, school-level Earth science enrollment acted as a partial mediator for ethnic minority student enrollment, school level poverty, and the percentage of English language learners.This suggests that increasing Earth science access may have a long-term impact on geoscience equity, literacy, performance, and interest in the field, particularly for traditionally marginalized students.

Strand 14: Environmental Education and Sustainability

K-12 Science Teachers' Awareness and Use Regarding Climate Change Educational Resources From U.S. National Parks

Breanna Beaver, Youngstown State University, USA
Lisa Borgerding*, Kent State University, USA
Shannon Navy, Kent State University, USA
Edward Bolden, Kent State University, USA

ABSTRACT

Climate change education is essential to combat global climate change. However, teachers face several barriers to climate change instruction, including access to quality resources. The U.S. national parks are an informal sector offering various climate change educational resources (CCER). However, there are gaps in understanding teachers' awareness and use of these resources. This mixed methods explanatory sequential study surveyed 209 K-12 science teachers to better understand their awareness and use of CCER from U.S. national parks. A subset of the sample (n=18) completed qualitative interviews. Findings indicate that teachers have a low level of awareness for the CCER offered by US national parks and are least aware of PD opportunities. Teachers most often use field trips and website content. The qualitative sample identified reasons and barriers to use. The most frequently cited reasons for using CCER included local connections, general learning opportunities, and quality. The most common barriers included logistics, cost, and curriculum alignment. Implications are shared for science teachers, informal sectors, and educational scholars.

Strand 6: Science Learning in Informal Contexts

Comunidad de Ciencia: Latina Girls' Interactions with their Parents during Family Problem-Based Learning Science Activities

Katherine Short-Meyerson*, University of Wisconsin Oshkosh, USA
Peter Rillero*, Arizona State University, USA
Margarita Jimenez-Silva, University of California Davis, USA
Cameron Bilardello, University of Wisconsin-Madison, USA

ABSTRACT

This paper describes an empirical research study of a science enrichment program for fifth- and sixth-grade Latina girls and their parents. It reports findings from 13 families who took part in a 7-week pilot science program held on Saturday mornings. The main component of the program was Family Problem-Based Learning (FPBL) science activities. There were two distinct program topics (rocketry and gardening) in two locations (California and Arizona).

The parent and daughter behaviors during 49 video- and audio-recorded FPBLs were examined as a function of week in the program, daughters' age, and program (topic/location). Findings included (1) changes over time in the daughters' help-seeking, "aha" moments, and talkativeness; and the parents' providing help, "aha" moments, and talkativeness, (2) differences in daughters' "aha" moments and encouragement/praise as a function of daughter age; differences in parents' helping, moments of frustration, "aha" moments, slowing their daughters, and encouragement/praise as a function of daughters' age, and (3) numerous differences in daughters' and parents' behaviors as a function of program (i.e., topic and location). Implications for designing and implementing science programs in out-of-school settings as well as classroom settings are discussed.

Strand 8: In-service Science Teacher Education

How Autonomy and Support Impact the Implementation of New STEM Frameworks and Teacher Retention Intentions

Jenna Zietowski*, Saint Joseph's University, USA

ABSTRACT

This study examined the influence of autonomy, administrative support, and school environment on the retention intentions of beginner STEM teachers and their ability to use new curriculum frameworks. Teachers who went through a fellowship program where they were trained in a new STEM framework called Education for Sustainability (EfS) were interviewed. This commonality allowed for an analysis into what factors influence a teacher's ability to implement new science frameworks. Three teachers had strong intentions to remain in their current school while three did not and one teacher ranked with moderate retention intentions. Factors of administrative support, autonomy, and school climate were linked within a teacher's experience and directly impacted their retention intentions. Four different categories of autonomy emerged. Positive-high autonomy was a proportional mix of flexibility and support and resulted in the greatest retention intentions and ability to implement EfS. Negative-high autonomy had lots of flexibility but little support and resulted in low retention intentions and an inability to implement EfS. Low autonomy had a very rigid curriculum and no room to implement EfS. Medium autonomy had mixed results depending on the other supports given. Subject-specific mentorship was the most helpful support, resulting in the highest retention intentions.

Strand 11: Cultural, Social, and Gender Issues

Ultra-orthodox women's choice of STEM studies and career

Ruth Edri, Technion - Israel Institute of Technology, Israel
Shani Goldstein*, Technion - Israel Institute of Technology, Israel
Shahaf Yoel, Technion - Israel Institute of Technology, Israel
Yehudit Dori, Technion - Israel Institute of Technology, Israel

ABSTRACT

Globally, there is a shortage of STEM workers. In Israel, there is unrealized potential in these domains for ultraorthodox, who want to work in a socially and financially mobile workplace. The study focuses on STEM career choices and career development for ultra-Orthodox

women. SCCT suggests that self-efficacy, self-expectations, environmental, and behavioral variables influence higher education and career choice. The research applies a mixed-methods approach, which includes a questionnaire as the quantitative tool and interviews as the qualitative tool. Thirty-four ultra-Orthodox women who work in STEM fields responded to the questionnaires, and two of them were interviewed. Preliminary results show that around 30% of the women who pursue STEM careers do so for financial reasons, but they are dissatisfied from inappropriate salary. Two new categories in SCCT have emerged: (1) Occupational history and workplace environment—environmental theme, (2) Salary inequalities—behavioral theme. The methodological contribution stems from the dedicated questionnaire and the interview protocol that were developed based on validated tools from previous studies and adapted for high-tech requirements guide for interviewing ultra-Orthodox women working in STEM. The theoretical contribution is the expansion of SCCT to understand better the various categories influencing career choice among underrepresented populations.

Strand 12: Technology for Teaching, Learning, and Research

Orchestrating Learning Communities Across Three Social Planes with Learning Community Technologies

Dana Gnesdilow*, University of Wisconsin, USA
Michael Tissenbaum, University of Illinois Urbana-Champaign, USA
Xuesong Cang, University of Wisconsin, USA
Litong Zeng, University of Illinois Urbana-Champaign, USA
Shafagh Hadinezhad, University of Illinois Urbana-Champaign, USA
Samantha Baker, University of Wisconsin, USA
Diane Gengler, University of Wisconsin, USA
Sadhana Puntambekar, University of Wisconsin, USA

ABSTRACT

Teachers' orchestration of students' knowledge building in inquiry-based science contexts is challenging. We developed a technology to support knowledge building in the classroom across three social planes – individual, small group, and whole class – called the Idea Wall to assist teachers' orchestration of students' science learning during an inquiry-based biology curriculum. We examined the teacher's orchestrational moves across social planes when incorporating the Idea Wall in her classroom for the first time. The teacher's initial focus was on scaffolding students to learn how to use the tool, with a gradual transition to group and whole-class instruction focused on supporting students' collaboration and knowledge building. Our findings give evidence of the need for both teachers and students to appropriate novel tools into the classroom culture before they can be used as part of their collective knowledge building. Once achieved, such tools can help teachers orchestrate students' learning across multiple social planes.

Strand 12: Technology for Teaching, Learning, and Research

Physics Experiments Using Self-Made Applications for Smartphone and the Philosophical Significance

Akira Adachi*, Osaka Institute of Technology, Japan

ABSTRACT
The "Diracma" series of self-made applications (apps) have been developed, using which physics experiments can be performed. These apps have functions and usability that conventional apps lack. The "Diracma" series apps use smartphone built-in functions such as accelerometers and audio functions, as well as connect external sensors. Moreover, it is possible that these smartphone apps can be effectively used in online classes using students' smartphones. Unlike conventional school experiments, performing experiments on these apps is not restricted by location or time. The new physics education scheme was used in our class to improve the functions and usage of the apps. When examining smartphone apps as modern tools, we have discussed the significance of using apps and self-made apps from the perspective of both the theory of the relationship between people and tools and the theory of tools that improve the relationship between people. Educational methods using these modifiable apps may contribute to making students smarter as a human-centered technology (the effective use of reflective cognition) and re-tooling to enhance student's autonomous behavior (conviviality). The effective use of these apps is considered one of the possibilities for a new approach to learning.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Analysis of Primary Science Education in the United States Through the Lens of Practitioner Literature

Farnaz Avarzamani*, Arizona State University, USA
Samira Golshani, Islamic Azad University, Iran, Islamic Republic of
Ying-Chih Chen, Arizona State University, USA

ABSTRACT
We aimed to examine the integration of science and literacy in elementary school by analyzing scientific lessons taught in the United States over the previous decade, as reported in the journal Science and Children. The most common forms of science literacy we found were speaking, writing, and vocabulary. Reading and listening were given less weight than the ability to express oneself in written form. When it came to science practices, questions, plans, analyses, and explanations were emphasized more than computational thinking and the ability to communicate scientific findings.

Strand 1: Science Learning: Development of student understanding

Identifying Student Idea Trajectories in a Science-Based Social Justice Unit

Troy Wilson*, University of California, Berkeley, USA
Allison Bradford, University of California, Berkeley, USA
Libby Gerard, University of California, Berkeley, USA
Marcia Linn, University of California, Berkeley, USA

ABSTRACT
Learners bring multiple ideas about science and social justice to the science classroom. Constructivist pedagogy calls for identifying and building on these ideas to promote integrated science understanding. This study used rubrics designed for training a Natural

Language Processing (NLP) model to detect ideas in a social justice science essay. We tracked how students' ideas changed as they engaged in a web-based social justice science unit featuring connections between urban heat islands and climate change. Participants were 61 students taught by one teacher in 7th and 8th-grade classes in a school serving 94% Hispanic/Latino learners, 85% of whom qualified for free or reduced-price lunch. We identified 19 distinct ideas and detected them at three-time points in the unit: pretest, embedded test, and posttest. Across the unit, students made progress in integrating their understanding of the social justice science issue. Students were more likely to integrate science disciplinary ideas than to integrate social justice science ideas, consistent with the novelty of the social justice topic.

Strand 14: Environmental Education and Sustainability

Secondary School Science Students' Visions of Growing Personal Dispositifs

J. Lawrence Bencze*, OISE, University of Toronto, Canada
Dave Del Gobbo, Peel District School Board, Canada

ABSTRACT

'STEM' (science, technology, engineering and mathematics) education initiatives are influential. Many have seemed, however, to prioritize selection of few potential STEM workers. In doing so, they often compromise STEM-SE (STEM-Society-Environment) relationships—like climate crises and manipulative surveillance—that appear largely due to pro-capitalist dispositifs; i.e., networks of (a)biotic and symbolic actants prioritizing private profit. In collaborative action research to be reported here, an experienced high school science teacher aimed to educate 9th-grade students about numerous concepts from fields of Science and Technology Studies—including actor-network theory, dispositifs, commodity semiotic enticements, repressive vs. normalizing power and, especially, growth in dispositifs. Analyzing relevant teaching and learning materials, students' completed assignments and recorded interviews, we found that most students imagined 'quasi'-dispositifs—including multiple actants affecting undecided individuals and holistic network maps. In doing so, students' ontologies, epistemologies, methodologies and axiologies seemed changed. Among possible influencing factors, including local curricula, the teacher and students, the teacher's creative uses of Latour's (1990) example of adding cooperating actants to encourage patrons to leave keys at the hotel seemed very helpful. Results seemed hopeful for increasing literacy for all, but likely will require growing educational dispositifs; e.g., cooperation among government, businesses, workers, etc.

Strand 8: In-service Science Teacher Education

A Design-based Course for STEM Teaching and Learning in Pakistan

Tasneem Anwar*, Aga Khan University, Pakistan

ABSTRACT

This study presents an analysis of the iterative design, implementation and re-design of a novel elective course named 'STEM Teaching and Learning,' introduced for the first time in Spring 2023 within a teacher education program in Pakistan. Employing a design-based research (DBR) methodology, the research examines the evolution of this course's impact on

in-service teachers, aiming to equip them with the theoretical foundation and practical skills required to integrate STEM education into the emerging Pakistani science curriculum. Focusing on the question of how a design-based course enhances participants' ability to apply STEM as a pedagogical approach and create effective STEM curricular units, the study integrates diverse qualitative data sources, including facilitator notes, participant reflections, ideation processes, STEM unit drafts, microteaching artifacts, self and peer assessments, and STEM Integration Curriculum Assessment (STEM ICA) scores. The findings are structured into four primary themes: the progression of participants' STEM conceptions, the challenges encountered in developing STEM curricular units, the emergence of vicarious STEM learning, and the complexities of achieving true STEM integration. The study's implications extend to graduate courses, practitioners, and similar audiences, while its design principles offer valuable guidance to educational designers.

Multi-Strand Stand-Alone Paper Set 9

8-Mar-24, 10:15 AM-11:15 AM
Location: Zoom B

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Attitudes Toward Science among Grades 5 through 12 Students: Response Profiles, Background, and Future Intentions

Siqi Shen*, Shanghai Jiao Tong University, China
Ryan Summers*, University of North Dakota, USA
Shuai Wang*, Shanghai Jiao Tong University, China

ABSTRACT

The present study explored the profiles of attitudes toward science among students across grades 5 through 12 in the United States, and further investigated the relations between their profile membership, intentions to engage in science, and individual background variables. Latent profile analysis revealed three distinct profiles: unfavorable outlooks, moderate outlooks, and favorable outlooks. Results showed that students in profiles with higher levels of outlooks showed greater intentions to engage in science. Gender, frequency of talk, and perceived science ability predicted a higher likelihood of favorable outlooks.

Strand 10: Curriculum and Assessment

Developing an Evaluation Rubric for Planning and Assessing SSI-Based STEAM Programs in Science Classrooms

Ha My Anna Mang*, Macquarie, Australia
Hye-Eun Chu*, Macquarie, Australia
Sonya Martin, Seoul National University, Republic of Korea
Chan-Jong Kim, Seoul National University, Republic of Korea

ABSTRACT

This multi-phase study designed a program evaluation rubric which used a qualitative rating system to help teachers identify key learning goals, dimensions, and principles related to the socio-scientific issues (SSI)-based science, technology, engineering, arts and mathematics (STEAM) approach for science education. This rubric contains 37 criteria that address one or more key principles of the SSI-based STEAM approach embedded in a 6E inquiry-based instructional model. It is organised into seven evaluation categories: (1) learning outcomes, (2) engage, (3) explain, (4) explore, (5) elaborate, (6) evaluate, and (7) enact. The newly developed rubric was used to evaluate six different climate change programs to determine whether it could measure the intended dimensions and principles and to assess its applicability across varying contexts. This research has implications for providing a tool for teachers to plan and design SSI-based STEAM programs.

Strand 7: Pre-service Science Teacher Education

Effect of Adaptive Expertise in Math/Science Teaching on Preservice Teachers' Attitudes Toward iSTEM Teaching

Mounir Saleh*, University of Bahrain, Bahrain
Bashirah Ibrahim, University of Bahrain, Bahrain
Ernest Afari, University of Bahrain, Bahrain

ABSTRACT

Integrated Science, Technology, Engineering, and Mathematics (iSTEM) teaching prepares students for 21st-century challenges. Nevertheless, teachers' attitudes toward iSTEM teaching influence its implementation. A promising factor that impacts these attitudes is adaptive expertise (AE). Teachers with AE tend to show willingness and ability to learn and innovate new teaching approaches. Prior work showed that AE in science teaching positively impacts iSTEM attitudes. Here, we explore the interaction effect between adaptive expertise in science and math teaching on preservice teachers' attitudes toward iSTEM teaching. We used a cross-sectional survey method with 104 senior preservice teachers. Regression analysis revealed that the higher the adaptive expertise in math teaching, the stronger the effect of adaptive expertise in science teaching is on iSTEM attitudes. This suggests that an adaptive science teacher would possess a positive attitude toward iSTEM teaching. This science teacher would exhibit even better iSTEM attitudes if they also gained adaptive expertise in math teaching, since they would feel confident addressing students' mathematical needs in an iSTEM activity. These outcomes have promising implications for the design of science teacher preparation programs.

Strand 7: Pre-service Science Teacher Education

Effectiveness of Online Science Laboratory Course on Pre-Service Science Teachers' Efficacy Beliefs and Epistemological Beliefs

Ozgul Yilmaz-Tuzun, Middle East Technical University, Turkey
Cansu Basak Uygun*, Middle East Technical University, Turkey
Ceren Baser-Kanbak, Middle East Technical University, Turkey
Coskun Aykut, Middle East Technical University, Turkey

ABSTRACT

The purpose of the present study is to investigate the effect of an online science laboratory course on pre-service science teachers' (PSTs') efficacy beliefs, personal science teaching

efficacy (PSTE) and science teaching outcome expectancy (STOE), and epistemological beliefs, the dimensions of source, certainty, development, and justification. For this purpose, one group pre-test post-test experimental design was utilized. A total of 20 junior PSTs consisted of the sample of the present study. PSTs' efficacy and epistemological beliefs were obtained through STEBI-B (Enochs & Riggs, 1990) and Epistemological Beliefs Questionnaire (EBQ) (Conley et al., 2004), respectively. Paired sample t-tests were conducted to analyze the differences in PSTs' efficacy and epistemological beliefs before and after participating in the online science laboratory course. Descriptive statistics regarding both STEBI-B and EBQ showed that PSTs' mean scores on all dimensions in the post-test were higher than those in the pre-test. The results of paired sample t-tests indicated that the difference in only PSTE mean scores was found statistically significant. The present study might have the potential for teacher education programs in consideration of planning specific activities to improve future teachers' efficacy and epistemological beliefs.

MID-DAY BREAK
8-Mar-24, 11:15 AM-12:15 PM
Location: Zoom A

Multi-Strand Stand-Alone Paper Set 3
8-Mar-24, 12:15 PM-1:15 PM
Location: Zoom A

Strand 8: In-service Science Teacher Education

Focused on Our Children's Future: Supporting and Studying Socially Responsible Science Education Through Professional Development

Travis Fuchs*, Crofton House School, Canada
Yuen Sze Tan, University of British Columbia, Canada

ABSTRACT
This study investigates the implementation of socially responsible science education (SRSE) through a Learning Study among high school science teachers. Three distinct approaches to SRSE emerged: Balanced, Transformative, and Collective Action. The Balanced Approach focused on developing engaged critics through cognitive and conceptual knowledge. The Transformative Approach aimed to promote personal action and attitude shifts. The Collective Action Approach sought to engage students in collective social actions. These approaches highlight the complexity and contextual nature of SRSE implementation, with each offering unique opportunities and challenges. The findings underscore the significance of teacher professional development in supporting nuanced and responsive SSI-based practices. They also have implications for curriculum reform, emphasizing the need for context-specific approaches, collaborative learning environments, and support structures that empower students to critically engage with socioscientific issues and cultivate social responsibility.

Strand 6: Science Learning in Informal Contexts

Evaluating the Credibility of Online Sources: The Case of Climate Change Misinformation in Three Languages

Shakked Dabran- Zivan*, Faculty of Education in Science and Technology, Technion – Israel Institute of Technology, Israel
Ayelet Baram-Tsabari, Faculty of Education in Science and Technology, Technion – Israel Institute of Technology, Israel
Rebecca Kunze, Institute of Science Education, Leibniz University, Germany
Soraya Kresin, Institute of Science Education, Leibniz University, Germany
Alexander Büssing, Institute of Science Education, Leibniz University, Germany

ABSTRACT
Science education should be a part of the solution to the spread of scientific misinformation, by equipping the public with the tools to assess the reliability of scientific information, even when it's beyond their understanding. While increasing attention is given to identifying misinformation online, empirical research on the effectiveness and constraints of various screening criteria is lacking. This research aims to test the efficacy of different criteria in identifying climate change misinformation online (defined as information that contradicts the scientific consensus) and to assess whether these criteria are equally effective in different languages. A content analysis of 121 Google search results (SERPS) in English, German, and Hebrew was performed, addressing issues of source trustworthiness and expertise. Although the findings indicate that acknowledging the source and conflicts of interest are effective criteria for identifying misinformation, the study highlights challenges in evaluating online sources in Google search results. The study also found the varying effectiveness of these criteria between languages. Surprisingly, in German, knowing more about the author's background might actually hinder the detection of climate change misinformation. Our findings, therefore, reinforce the need to understand digital and scientific literacy at the societal level and not just the individual level.

Strand 6: Science Learning in Informal Contexts

Exploring the Role of Psychological Distance in Scientists' Climate Change Outreach

Rebecca Ward*, North Carolina State University, USA
Melissa Jones, North Carolina State University, USA
Katy May, North Carolina State University, USA

ABSTRACT
When problems are perceived as distant, people may be less motivated to take action about them. A large body of literature on research-based best practices for climate change educational outreach suggests that reducing the perceived psychological distance between individuals and climate change can heighten awareness, risk perception, and motivate action to address this global issue. Scientists and scientific organizations play an important role in educating the public about climate change through effective communication, outreach, and engagement activities, yet little is known about how they frame the issue as psychologically close or distant. A survey-based research study was conducted to explore

scientists' use of psychological distance in their climate change outreach engagements. Findings revealed that scientists' practices generally follow evidence-based recommendations by prioritizing closer psychological distances. However, participants in this study also used of a range of distance cues when describing climate change that could encourage their audiences to consider this as both a close and distant issue, which may or may not encourage awareness or motivation toward action. This study provides important insight into how scientists are currently communicating about climate change.

Strand 8: In-service Science Teacher Education

Effects of Meta-Strategic Training Program for Relational Reasoning Skills on In-Service Biology Teachers' Expertise Level

Vered Alboher Agmon*, Alexandru Ioan Cuza, University of IAȘI, Romania

ABSTRACT

This study examines how biology teachers' training program with relational reasoning skills affects their knowledge, understanding, and strategies for overcoming their application difficulties. The study was conducted in the context of a) The gap between available information flows and students' and teachers' ability to organize it efficiently to generate knowledge. b) The need for biology teachers to explain scientific principles in depth by creating meaningful relations at multiple levels to promote students' understanding. Relational reasoning skills, analogy, antinomy, anomaly, and antithesis, allow efficient identifying relations patterns in complex data, studied mainly with students in diverse disciplines. This mixed-method study expands the literature by examining forty-five in-service teachers in Israel who teach in 7-12 grades, divided into intervention and control groups, and tested pre-post with RRs. Results show that intervention teachers' RRs application and knowledge performance improved significantly due to an explicit high-thinking learning method, including developing meta-strategic knowledge and receiving cognitive actions tool for mapping higher relations. However, only 16% of intervention teachers could apply Relational Reasoning skills to explain in-depth biological phenomena. Furthermore, teachers' ability to develop coping strategies in RRs application related to their knowledge level performance- indicating teachers' expertise level and the need for additional practice.

Multi-Strand Stand-Alone Paper Set 4

8-Mar-24, 12:15 PM-1:15 PM
Location: Zoom B

Strand 7: Pre-service Science Teacher Education

Negotiating Dilemmatic Spaces: Preservice Teachers' Challenges as They Learn to Assess Science Learning

Frances Edwards*, University of Waikato, New Zealand

ABSTRACT
The purpose of this paper is to draw attention to the tensions and influences on preservice and beginner science teachers as they learn to make decisions about assessment. It focuses on the decisions related to summative assessment, made while working in science classrooms. Honig's (1996) concept of dilemmatic space is used as a theoretical framework to highlight the complexity of assessment decision making. Using a qualitative approach data was gathered through a series of spaced interviews in a study that tracked eight beginner science teachers through their one-year teacher education programme and the first year of their employment as science teachers. They were found to be affected by ever-present pressures and tensions from a number of sources as they made assessment related decisions. This led to a wide range of actions which were, at varying times, in alignment or in conflict with school expectations and mentor teachers' instructions. Their decisions were found to be underpinned by their commitment to encouraging students to remain engaged in learning science. Implications for teacher educators and schools are discussed.

Strand 8: In-service Science Teacher Education

Facilitating Science Discourse and Argumentation: Teacher Participation and Learning in Professional Development

Florencia Gomez Zaccarelli*, Pontificia Universidad Catolica de Chile, Chile
Victoria Arriagada Jofre, Pontificia Universidad Catolica de Chile, Chile
Jocelyn Gaete-Cornejo, Pontificia Universidad Catolica de Chile, Chile

ABSTRACT
This study focuses on the role of teacher professional development (TPD) in enhancing elementary science teachers' abilities to facilitate scientific discussions and argumentation in the classroom. The TPD program included group workshops and coaching sessions spanning 12 weeks. The researchers analyzed TPD records and interviewed teachers at different stages to comprehend their participation and perceptions of learning. Through coding and analysis, the study identified instances of scaffolding, challenges, needs, and practices during the TPD. The findings revealed that scaffolding and sharing teaching practices were crucial aspects of the TPD that helped teachers overcome challenges, particularly in planning science discussions and argumentation. Teachers emphasized the importance of school-wide alignment and ongoing professional development in the interview phase. Ultimately, the study aims to provide insights into teachers' preferences, needs, and challenges during TPD, shedding light on effective strategies for supporting teachers in mastering complex teaching practices.

Strand 10: Curriculum and Assessment

Development and Validation of Biology Test for Senior High School STEM Students

Glen Mirabete*, De La Salle University, Philippines

ABSTRACT
Testing is among the essential components of assessment. Test results assess the knowledge and skills of students in learning the content of the subject area and help teachers identify the student's learning difficulties. School administrators use the test profile to determine the

best intervention and support systems for the students to reach their full potential. This study aimed to develop a biology test for STEM students using item analysis and distractor analysis. Results showed that the quantitative phase of this research had been tried out on 250 students at the school for the academic year 2021-2022. Correct and incorrect responses and options responses have been assigned and encoded for more data analysis. The reliability of the Kuder-Richardson 20 (KR-20) is 0.848, which means acceptable and can be used further for data processing. Measurement of discrimination and difficulty indices has been considered, and found that 50 items must be retained. The results of the study aim to shed light and contribute to the innovative processes in test development and educational assessment in the country.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Demystifying the Myths of Early Childhood Teachers' Engagement with Sustainability Practices

Lacey Peters*, Hunter College, CUNY, USA
Janette Habashi*, University of Oklahoma, USA
Victoria Damjanovic*, Northern Arizona University, USA
Ingrid Anderson, Portland State University, USA

ABSTRACT

Sustainability practices in early childhood contexts are key to mitigating the effects of climate change, and sustainable futures require individual and collective actions. This participatory action research investigated how early childhood (EC) educators engage in sustainability practices within localized contexts. The primary aims of the study were to 1) better understand educators' beliefs about sustainability 2) examine how educators identify sustainability practices, and 3) explore how sustainability beliefs and practices are implemented in EC programs. Researchers engaged a group of EC educators in a series of professional learning sessions and subsequent interviews to gain in-depth perspectives on the opportunities and challenges teachers encounter as they engage in sustainability practices. A thematic analysis of the transcripts revealed that three myths about EC sustainability practices are influencing teachers' engagement with sustainability education; sustainability is hard and inappropriate for young children, sustainability as a concept is a moving target, and it is too challenging to bridge the divide between environmental, social, and economic justice in EC spaces. Building awareness around these myths helps to challenge them, and leads to insights on how EC educators embed sustainability practices into the curriculum in a meaningful and maintainable way.

Multi-Strand Stand-Alone Paper Set 5

8-Mar-24, 1:30 PM-2:30 PM
Location: Zoom A

Strand 8: In-service Science Teacher Education

CT+CRT+Science: Pathways to Integration in Elementary Teachers' Lesson Plans

Jeremy Bernier*, Arizona State University, USA
Kristina Kramarczuk, University of Maryland, USA
Ebony Terrell Shockley, University of Maryland, USA
Francheska Figueroa, Arizona State University, USA
Lin Yan, Arizona State University, USA
Yue Xin, University of Maryland, USA
Janice Mak, Arizona State University, USA
Man Su, Universität des Saarlandes, Germany
Diane Ketelhut, University of Maryland, USA
Brian Nelson, Arizona State University, USA

ABSTRACT

With this manuscript, we discuss the outcome of a pair of professional development workshops where we sought to foster elementary teachers' learning about Computational Thinking and Culturally Responsive Teaching in science education. 34 teachers from three school districts participated across two workshops, during which they modified existing science lessons. We used content analysis and our own framework for Culturally Responsive Teaching to analyze the practices teachers chose to integrate into their lesson. We found that while one of our practices (Model High Expectations) was incorporated by almost all teachers, two practices were included only rarely and one practice (Speak up About and Respond to Prejudice, Bias and Stereotypes) was not included by any teacher. We provide illustrative examples of these practices using two posters. In our discussion, we offer some conjectures for why teachers may have been reluctant to implement this practice into a science lesson and how one might encourage teachers to do so. Finally, we conclude by discussing how we leveraged our diversity as a research team to strengthen our process, and how this validates our overarching goal of increasing diversity in STEM fields.

Strand 8: In-service Science Teacher Education

Science Teachers' Sensemaking of and Approaches to Artificial Intelligence Integrated Science Teaching

Won Jung Kim*, Santa Clara University, USA
Arif Rachmatullah*, Stanford Research Institute, USA

ABSTRACT

Numerous countries, including South Korea, are pioneering national initiatives to incorporate artificial intelligence (AI) education into their educational systems. This study presents a case of a teacher learning program designed to guide teachers on implementing AI in science classrooms. The primary data sources were peer-teaching videos created by the teachers to share their experiences in integrating AI into science classes, along with individual semi-structured interviews. Using the organizational sensemaking theory to analyze the data, three modes of teacher sensemaking were identified: Critical questioning; Learning by teaching and designing to teach; and Identifying opportunities and challenges. These modes, originating from uncertainties and ambiguities about the policy changes, served as mechanisms for science teachers to explore, demonstrate, and reflect on their approaches to AI-integrated science teaching, from which three approaches were discerned: Try it Out, Train it and Test, and Explore the Epistemic. We identified these approaches according to the assumptions on which aspects of AI were prioritized to integrate and instructional strategies teachers demonstrated or suggested. This paper discusses these sensemaking modes and approaches in the context of future PD programs and emphasizes that the emerging shifts towards AI-integrated science education should be collectively addressed, without burdening teachers exclusively.

Strand 11: Cultural, Social, and Gender Issues

Views on STEM (Education) in an Elite School: A 'Platonic Legacy'

Majd Zouda*, University of Toronto, Canada

ABSTRACT

Despite the plethora of research about STEM education, a still underexplored area of such research is elite schools. Elite schools are well-known for their significant roles in socializing their students into elite groups and preparing them to assume leadership roles, contributing as such to social stratification. When acknowledging that STEM fields tend to have and produce their own status hierarchy, and that a main goal of dominant forms of STEM education is to 'improve skilled STEM workforce', examining how STEM education is conceptualized and practiced in elite schools, and for what purposes, can then provide better understanding of, and new insights on, privilege making and social inequity. Using Critical Discourse Analysis, this research examines meanings of excellence and distinction in STEM (education) in an elite, independent co-educational high school in Canada. It particularly reports on available views on technology and how these conceptualizations might contribute to elite identification. Findings revealed an overarching discourse of leadership that largely shaped valued STEM learning experiences. Findings also revealed selective embracement of what is perceived as high-status STEM knowledge and fields, with adopted meanings of technology prioritizing understanding concepts, ways of thinking, and academic ties. Significance of these findings are discussed.

Strand 7: Pre-service Science Teacher Education

Promoting Science Preservice Teachers' Competencies through Phenomenon-Based Science Instruction: The Lotus Effect Activity

Noushin Nouri*, The University of Texas Rio Grande Valley, USA
Maryam Saberi, ministry of education, Islamic Republic of Iran
Samira Bahrami, Department of physics education, Farhangian University, Islamic Republic of Iran
Somayeh Samari, Ministry of education, Islamic Republic of Iran

ABSTRACT

Phenomenon-based learning (PhBL) is an active science teaching method recommended by NGSS, aimed at effectively facilitating students' learning of science content, science and engineering practices, and crosscutting concepts. This approach carries significant

credibility, as it originates from Finland, a recognized leader in education. While there are many reasons for replacing this approach with topic teaching in science classes, this movement still requires prepared teachers and enough materials. Teachers need to possess extensive pedagogical competencies encompassing knowledge, skills, and attitudes to effectively design and implement phenomenon-based science instruction. This article contributes to the ongoing effort by introducing these essential competencies (called PhBL competencies) and step-by-step explaining the application of one potential phenomenon (i.e., Lotus effect) used in a preservice setting to assist teachers in developing their desired PhBL competencies. The 15-hour workshop was divided into two parts: Part 1 focused on teaching science using the PhBL approach, while Part 2 elucidated the foundational aspects of PhBL and its alignment with NGSS. Our findings demonstrate the workshop's effectiveness in supporting science preservice teachers in both learning about and designing phenomenon-based science instruction.

Multi-Strand Stand-Alone Paper Set 6

8-Mar-24, 1:30 PM-2:30 PM
Location: Zoom B

Strand 5: College Science Teaching and Learning (Grades 13-20)

Role of Diagrams in Simultaneous Synthesis Physics Problem-Solving

Bashirah Ibrahim*, Bahrain Teachers College, University of Bahrain, Bahrain
Lin Ding, The Ohio State University, USA

ABSTRACT
We explore how students unpack the diagrams given in simultaneous synthesis tasks during problem-solving. Such tasks involve multiple events that occur concurrently, meaning at the same time and location. Using an eye tracker, we recorded students' eye patterns (text-diagram and within-diagram gaze transitions and eye fixation durations on various components of a diagram) when they silently thought of and then verbalized their problem-solving strategies. We also looked at their descriptions of problem-solving strategies. Results indicate that the students made more text-diagram than within-diagram gaze transitions. Moreover, they fixated heavily on the components of each diagram with information already given in the problem text, more so than on those requiring envisioning of future events and generation of new information. Further, the students predominantly failed to elicit all the pertinent concepts and intermediate variables. They prioritized information given in the problem text to find the intermediate variables. Overall, the diagram in each simultaneous synthesis task helps students in problem-solving to a certain extent.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Fostering Scientific Argumentation Through Tablet-based Interactive Technological Engagement

Yingzhi Zhang*, Capital Normal University, China
Pengcheng Shan, Capital Normal University, China

ABSTRACT
This study investigates the impact of interactive tablets on science argumentation teaching, comparing experimental and control groups using a quasi-experimental design. Participants in this study were drawn from a public high school in Beijing, China. A total of 31 tenth-grade students (aged 15-16) were enrolled, with one group as the experimental group (15 students, with tablets) and the other as the control group (16 students, without tablets). Researchers designed two instructional versions for the groups, encompassing 10 lessons for each group over two months, totaling 20 lessons (900 minutes). The Assessment of Scientific Argumentation in the Classroom (ASAC) observation protocol (Sampson, Enderle, & Walker, 2012) was employed to monitor students' argumentation. Results indicate a significant impact of tablet-based interactive learning environments on students' argumentation skills, with the tablet group demonstrating notable advancements. These findings provide valuable insights for science education, emphasizing the potential of technology in enhancing student learning and engagement.

Strand 7: Pre-service Science Teacher Education

Investigation of Pre-Service Teachers' Knowledge of Atmosphere Related Environmental Problems and their Systems Thinking Skills

Aylin Çam*, Muğla Sıtkı Koçman University, Muğla, Turkey
Harika Arslan, Düzce University, Turkey

ABSTRACT
The aim of this study is to examine the relationship between pre-service science teachers' knowledge and misconceptions about atmospheric environmental problems and their systems thinking skills in the context of climate change. For this purpose, case study design, which is one of the qualitative research methods, and convenient sampling method were used. Twelve pre-service science teachers voluntarily participated in the study. In order to determine the knowledge levels and misconceptions of pre-service science teachers about the atmosphere, the atmosphere related environmental problems diagnostic test was applied. In addition, they were asked to draw a concept map about climate change to determine their systems thinking skills. Then, interviews were held on concept maps. Pre-service science teachers' knowledge levels about atmospheric problems were found to be low. They have misconceptions; "global warming is caused by ozone layer depletion" and "recycling more paper is not an effective cure for global warming". In addition, the systems thinking skills of all pre-service science teachers are at the "emerging" level. This shows that there is a relationship between pre-service science teachers' knowledge and misconceptions about environmental problems related to the atmosphere and their systems thinking skills in the context of climate change.

Multi-Strand Stand-Alone Paper Set 7

8-Mar-24, 2:45 PM-3:45 PM
Location: Zoom A

Strand 11: Cultural, Social, and Gender Issues

Difficulty Gap in Students' Achievement, Creativity and Anxiety in ICT: Can CTCA Be a Bridge?

Henry Okorie*, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Peter Okebukola, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Adekunle Oladejo, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Juma Shabani, Doctoral School, University of Burundi, Burundi
Deborah Agbanimu, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria

ABSTRACT

This study investigates the effectiveness of CTCA in bridging difficulty gap in students' academic achievement, creativity and anxiety level in ICT concepts compared with Lecture method. This study adopted a mixed method design with pretest, posttest non–equivalent control group quasi-experimental design. The sample consisted of 58 students (25 males and 33 females) from two selected senior secondary schools. Three students from the experimental group were selected for interviews. The reliability coefficient of the achievement test (CNAT), creativity test (TCT), and anxiety scale test (DCAS) were 0.74, 0.70 and 0.95 respectively. The quantitative data were analysed using MANCOVA and qualitative data collected were analysed thematically. The findings revealed that the experimental group; CTCA outperformed the Lecture method group as the Multivariate (Pillai's Trace=0.37 ($F=9.52$; $p=0.00$)) and univariate Fs on achievement [$F(1,51)=12.03$;$p=0.001$]; anxiety [$F(1,51)=4.40$;$p=0.04$]and creativity [$F(1,51)=19.66$;$p=0.00$] attained statistically significant difference. CTCA was found not to have statistically significant difference on the three measures based on gender. Within the limitations of the study, it was inferred that CTCA can effectively promote meaningful learning by bridging the difficulty gap in students' academic achievement, reducing their learning anxiety level and promoting creativity.

Strand 12: Technology for Teaching, Learning, and Research

Adopting a Human-In-The-Loop Approach to Detect Persistence Types in a Guided Science Inquiry Environment

Shuo Feng*, School of Education, Shanghai Jiao Tong University, China
Maohua Wang, Shanghai Municipal Education Commission, China
Shuai Wang, School of Education, Shanghai Jiao Tong University, China
Siqi Shen, School of Education, Shanghai Jiao Tong University, China

ABSTRACT

This study addresses the significance of persistence types within guided science inquiry environments (GSIEs) and the need for corresponding detection methods. Previous research has primarily relied on human experience to deduce persistence types, with limited attention to the GSIE context and the role of domain knowledge. To address these gaps, our study adopted a human-in-the-loop approach, combining human and machine intelligence.

Through an experiment conducted on a real-world dataset, we leveraged domain knowledge and machine learning results to generate meaningful labels for persistence types. Additionally, we incorporated domain knowledge to construct sophisticated features. Comparative analysis of different models employing multiple algorithms revealed that the fine-grained model, enriched with domain knowledge, exhibited superior performance. This study underscores the significance of domain knowledge in education for the advancement of artificial intelligence, bridging the domains of science education, learning analytics, and computer science.

Strand 14: Environmental Education and Sustainability

Disaster Risk Reduction Education Literature Review and Proposed Research Agenda

Douglas Lownsbery*, Independent Researcher, USA

ABSTRACT

We provide a critical interpretive synthesis review of the extant English language literature on disaster risk reduction (DRR) education for natural hazards. We examine the current literature in order to identify and describe the strengths, limitations, and gaps in our knowledge, and to posit explanations for why that current status exists. Based on the results of that literature review, we then propose a nascent research agenda to guide the field forward with the overall goal of greater access, inclusion, and effectiveness of DRR education. This overall goal is aligned with the universal call in the DRR literature for not only increased DRR educational curriculum and activities for K-12 students and learners of all ages, but also the increased effectiveness of those activities in support of the priorities of the United Nations International Strategy for Disaster Reduction (UNISDR) Sendai Framework for Disaster Risk Reduction 2015-2030 (UNISDR, 2015). The goal of greater access, inclusion, and effectiveness of DRR education is highly aligned with calls in the science education literature for greater inclusion of socio-scientific issues that are highly relevant in students' lives and that engage students as agents of change in addressing real-world problems that affect their lives.

Strand 15: Policy, Reform, and Program Evaluation

Physical Science Enrollment and Performance as Predictors of Graduation and Mediators of Socioeconomic Status

Jon Hatzfeld*, Stony Brook University, USA
Robert Krakehl, Stony Brook University, USA
Angela Kelly, Stony Brook University, USA

ABSTRACT

A high school diploma has become the key to accessing many post-secondary opportunities including higher education and employment. This cross-sectional, observational non-experimental study focused on understanding the extent to which school-level academic performance and enrollment in the physical sciences (Earth science, chemistry, and physics) could mediate the predictive value of socioeconomic status on graduation rates in New York State. Data were collected from 1,261 schools, of which 555 reported enrollment and passing rates on standardized assessments in all three physical sciences. A structural equation model

was created to account for the hierarchical nature of the sciences and to control for the influence of school size. Results indicated that chemistry enrollment and Earth science performance partially mediated the effects of poverty on graduation rates. These results may provide high needs schools a roadmap for increasing graduation rates through targeted interventions that increase chemistry enrollment and Earth science performance.

Multi-Strand Stand-Alone Paper Set 8
8-Mar-24, 2:45 PM-3:45 PM
Location: Zoom B

Strand 15: Policy, Reform, and Program Evaluation
Embracing Mortality: Integrating Death Education into the K-12 Science Curriculum for Holistic Science Literacy
Rachel Ruggirello*, Washington University in St. Louis, USA
Sonya Martin*, Seoul National University, Democratic People's Republic of Korea

ABSTRACT
This study addresses a crucial need — the integration of death and dying education into K-12 science curricula. With daily exposure to death-related issues, students lack a holistic understanding of death's biological, emotional, and societal dimensions. This research examines historical approaches and contemporary curriculum trends related to death education in the context of school science. Via an extensive literature review, we trace the historical evolution of death education and its teacher training links. Subsequently, keyword-based searches across databases unearthed insights into death education's presence in science standards. Key documents such as the Framework for K-12 Science Education and Next Generation Science Standards were analyzed for mentions of death-related terms, offering insights into commonalities and disparities. This analysis was bolstered by an examination of life cycle-focused curricular materials, providing concrete examples. The study highlights the dearth of death-related content in K-12 science education and underscores the need for nuanced science literacy to address this essential aspect of life. We conclude with a discussion about importance of teacher training, curriculum design, and policy adjustments to collectively bridge the gap and better equip students with vital knowledge and skills to navigate complex issues related to death and dying in the 21st century.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Shaping Perspectives: Contrasting Student Framing in Evolutionary Research Between Computer-based Labs and Wet Labs
Dhanya Attipetty*, University of Minnesota, USA
Lily Dodge, University of Minnesota, USA
Anita Schuchardt, University of Minnesota, USA
Catherine Kirkpatrick, University of Minnesota, USA

ABSTRACT
Multiple studies have examined student learning and perceptions of Course-based Undergraduate Research Experiences (CUREs; Auchincloss et al, 2014; Dolan, 2016). However, students' framing of their research has not been as well characterized. Framing of research provides the structure for data analysis and interpretation of findings in the context of existing theories (Kivunja, 2018). Therefore, one measure of whether students are situating their work in a broader context (a key feature of CUREs) is whether they frame their research as merely manipulating one variable to see what happens to another variable, or whether they situate their work in a theoretical framework, such as evolution. This study used a qualitative approach to examine how CBL and WL how students framed their CURE research projects about evolution. Most CBL groups framed their research in terms of evolution (EVO), while most WL groups framed their research as manipulation of variables (ME). A similar pattern was also seen when comparing students of the same instructor. This difference in framing between CBL and WL groups implies that laboratory context influences how students frame their research and connect to a scientific context outside the classroom.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Implementing Computer Science in Elementary Science Classrooms: An Elementary Teacher's Perceptions Over Four Years

Sarah Lilly*, University of Virginia, USA
Eric Bredder, University of Virginia, USA
Anne McAlister, University of Virginia, USA
Jennifer Chiu, University of Virginia, USA

ABSTRACT
As computer science (CS) is integrated in elementary science curricula, it is important to consider teachers' perceptions in how they access CS and support students to engage in CS skills and standards through NGSS-aligned activities. This single case study utilizes the Interconnected Model of Professional Growth (IMPG) to examine teacher change and explore the perspectives of a teacher, through semi-structured interviews, as he implements an NGSS-aligned unit over the course of four years. Findings indicate that the teacher perceived that changes in his practice helped inform changes in student outcomes and the curriculum and, in turn, these changes in outcomes further informed his teaching practice in the next iteration of the unit. Results highlight the importance of reflection and feedback as a way to impact the teaching practice of integrating CS in elementary science education.

Strand 13: History, Philosophy, Sociology, and Nature of Science

Exploring the Nature of Science Conceptions of University Science Professors Using the Family Resemblance Framework

Rana Baddour*, American University of Beirut, Lebanon
Saouma BouJaoude, American University of Beirut, Lebanon

ABSTRACT

Over the past few decades, research has been conducted on the nature of science (NOS), which is considered a critical component for achieving scientific literacy. This study aims to explore university science professors' views of NOS using a recent theoretical framework, which is the family resemblance approach (FRA). FRA is a comprehensive framework that presents NOS in terms of cognitive-epistemic and social-institutional systems, including eleven categories. Apparently, only two studies used the FRA as an analytical tool to explore scientists' views about NOS. Consequently, this study extends the emerging literature on the FRA by exploring the NOS conceptions of science professors in Country L context. The study used a mixed-methods approach and involved 35 professors teaching science-technology- and engineering-related subjects. Results obtained from a modified version of the reconceptualized-FRA questionnaire as well as semi-structured interviews revealed that the professors hold mixed NOS conceptions. While the categories of the cognitive-epistemic system were the most highlighted in the professors' responses, categories of the social-institutional system were less addressed. Interestingly, a new emerging theme related to epistemic affect was echoed by two professors in the interviews. The findings suggest practical and pedagogical implications for instruction and recommend future areas for research.

Plenary Session

Wrapping up!

8-Mar-24, 3:45 PM-4:20 PM

Location: Zoom A

---

17 MARCH 2024

Research Committee
Pre-Conference Workshop
Uncovering the Hidden Curriculum of DRK-12 Awards: Tips and Tools for Writing Successful NSF Grant Proposals
17-Mar-24, 8:00 AM-11:45 AM
Location: Governor's Square 10

Uncovering the Hidden Curriculum of DRK-12 Awards: Tips and Tools for Writing Successful NSF Grant Proposals

ORGANIZERS
Terrell Morton, University of Illinois Chicago, USA
Lani Horn, Vanderbilt University, USA

ABSTRACT
This workshop will comprise relevant information for writing and refining an NSF DRK-12 grant proposal. The participants will the chance to engage various resources and materials created by the leaders of CADRE (Community for the Advancement of Discovery Research in Education). These resources include but are not limited to how to craft a strong project narrative, identify a robust team, build community partners, and develop a worthwhile budget. Given the commitments expressed by NSF to diversify its portfolio, this workshop is geared towards early career scholars studying at or employed by historically underfunded institutions (i.e., MSIs, R2s, Teaching Institutions, Community Colleges). Early and mid-career scholars from underrepresented groups are also encouraged to participate.

Equity And Ethics Committee
Pre-Conference Workshop
Re-emphasizing the Roles of “Social” and “Cultural” in Science Learning
17-Mar-24, 8:00 AM-11:45 AM
Location: Governor's Square 11

Re-emphasizing the Roles of “Social” and “Cultural” in Science Learning

ORGANIZERS
David Steele, Alder Graduate School of Education, USA

PANELISTS
David Steele, Alder Graduate School of Education, USA
Gary Wright, University of Missouri, USA
Justice Walker, University of Texas at El Paso, USA

Julie Bianchini, University of California-Santa Barbara, USA
Alejandra Frausto Aceves, Northwestern University, USA
Daniel Morales-Doyle, University of Illinois- Chicago, USA
Bridget Mulvey, Kent State University, USA
Catherine Quinlan, Howard University, USA
Troy Sadler, University of North Carolina, USA
Dana Zeidler, University of South Florida, USA

ABSTRACT
Schools are socio-cultural institutions for democracy, yet are susceptible to reinscribing societal inequities, acting more as agents of social replication than of mobility. Meanwhile, research shows that emphasizing embedding cultural perspectives in classrooms can transform learning experiences to make them more conducive to social mobility and empowerment. Related to science teaching and learning, the National Research Council Framework underscores that science learning can be understood as a cultural accomplishment. Unfortunately, students from non-dominant communities often face opportunity gaps in their science education experience due to pervasive deficit orientations in both educators and policy makers. To counter this, we want to expand upon contemporary and future approaches that position sociocultural factors and epistemological beliefs about science as powerful and inextricable tools that: engage students in socioscientific learning; provide students with opportunities to build literacies necessary for seeing and solving complex, wicked problems. This workshop, therefore, serves as a reminder that science education best serves our students and communities when educators re-emphasize the social and cultural factors that impact the doing and learning of science. These inclusive approaches reposition youth as necessary agents in science learning, and center the social and cultural assets they bring to learning environments and communities.

Indigenous Science Knowledge (ISK-RIG)
Pre-Conference Workshop
Indigenous STEM Education: Perspectives from the Pacific Islands, the Americas and Asia
17-Mar-24, 8:00 AM-11:45 AM
Location: Governor's Square 12

Indigenous STEM Education: Perspectives from the Pacific Islands, the Americas and Asia

ORGANIZERS
Sharon Nelson-Barber, WestEd, USA

PANELISTS
Jerry Lipka, University of Alaska, Fairbanks, USA
Dora Andrew-Ihrke, University of Alaska, Fairbanks, USA
Bhaskar Upadhyay, University of Minnesota, USA
David Zandvliet, Simon Fraser University, Canada

Janice Mak, Arizona State University, USA
Paichi Shein, National Sun Yat-sen University, Taiwan
Peresang Sukinarhimi, National Sun Yat-sen University, Taiwan
Lenora Crabtree, University of North Carolina, Charlotte, USA
Pauline Chinn, University of Hawaiʻi, Mānoa, USA

ABSTRACT

Many Indigenous innovations and practices are not known to mainstream science research and education communities and go unrecognized as benefiting current society. We have invited speakers and participants who bring uniquely Indigenous points of view to the educational transformation efforts taking place in their distinct contexts. Indigenous theory and research will undergird the presentation of authentic stories used to explain ways in which dominant disciplinary policies and practices can impact Indigenous students' participation in STEM classrooms and careers. Speakers and participants will discuss ways to engage learners in STEM activities that are interconnected with the contexts of their lives. Across the United States, Pacific Islands, Canada, Taiwan, and Nepal—Indigenous educators utilize storytelling, place, language and experiential learning to engage students in meaningful, highly contextualized study that honors ancestral knowledge and practices. Speakers and presenters will discuss ways to apply these processes to interventions in schools, communities, teacher education, and professional development. The session addresses the growing recognition that interdisciplinary, cross-cultural and cross-hybrid learning is needed to foster scientific and cultural understandings and move STEM learning toward more just and sustainable futures for all learners.

Membership Committee
Sponsored Session
Mentor/Mentee Nexus
17-Mar-24, 8:00 AM-9:00 AM
Location: Governor's Square 15

Mentor/Mentee Nexus

ORGANIZERS
Harini Krishnan, Genetic Science Learning Center, University of Utah, USA
Grant Gardner, Middle Tennessee State University, USA

ABSTRACT

The membership committee hosts an annual Mentor-Mentee Nexus. This 1-hour session serves as a context for first-time attendees or those relatively new to NARST to interact with more experienced NARST members. Session leaders facilitate the introduction of Mentors and Mentees by identifying and matching interested parties, creating an environment that supports communication among Mentors and Mentees, and monitors and evaluates mentor and mentee needs with respect to the NARST session. During the session, Mentors provide insight regarding topics of interest to the Mentee by either providing answers to Mentee

questions or helping the Mentee identify an appropriate source of information. During the session, Mentees locate their Mentor and in a small group share questions, concerns, and insights with their Mentors and other Mentees.

Membership Committee
Sponsored Session
Early Career Forum
17-Mar-24, 9:10 AM-10:10 AM
Location: Governor's Square 15

Early Career Forum

ORGANIZERS
Joi Merritt, James Madison University, USA
Harleen Singh, California State University Stanislaus, USA

ABSTRACT
The Early Career Forum introduces junior faculty members and post-doctoral fellows to peers, to a panel of recently promoted colleagues, and prominent scholars. The forum will focus on the nuances of succeeding during the early career years. Our discussions will include issues of developing and maintaining a research agenda (e.g., publications & grant writing), adhering to teaching responsibilities, and effective ways for engaging in meaningful service experiences. In addition, the forum will explore many of the challenges related to maintaining balance in your life in the process.

Membership Committee
Sponsored Session
Welcome Session
17-Mar-24, 10:20 AM-11:20 AM
Location: Governor's Square 15

Welcome Session

ORGANIZERS
Melanie Kinskey, Sam Houston State University, USA
Robert Bennett, Georgia State University, USA
Mihwa Park, Texas Tech University, USA

PANELISTS
Melanie Kinskey, Sam Houston State University, USA
Robert Bennett, Georgia State University, USA
Mihwa Park, Texas Tech University, Texas, USA

ABSTRACT
The Welcome Session, organized by the NARST Membership Committee, will be a 1-hour event where new members, first-time in person attendees, and practitioners are provided with conference logistics as well as opportunities to make connections with others and ask questions relevant to navigating the NARST experience. The Welcome Session is a communal space to learn about the functioning of NARST with little to no judgment while also fostering relationships with peers. Developed by the Membership Committee, attendees will hear from NARST Leadership and other key constituents who will share about their own relationship to NARST and what keeps them coming back. Additionally, attendees will also be provided with information regarding spotlight sessions and opportunities for involvement with the organization.

Research Committee
Pre-Conference Workshop
Conducting High-Quality Education Research in Science for the Rest of Us
17-Mar-24, 8:00 AM-11:45 AM
Location: Governor's Square 16

Conducting High-Quality Education Research in Science for the Rest of Us

ORGANIZERS
Leigh Ann DeLyser, CSforALL, USA
Isabella Gransbury, North Carolina State University, USA
Monica McGill, CSEdResearch.org, USA
Jennifer Rosato, National Center for Computer Science Education, USA

PANELISTS
Isabella Gransbury, North Carolina State University, USA
Monica McGill, CSEdResearch.org, USA
Leigh Ann DeLyser, CSforALL, USA
Jennifer Rosato, National Center for Computer Science Education, USA

ABSTRACT
Science Education for the Rest of Us infers that science education has primarily been created for dominant groups. As it stands, education research practices can ensure that dominant groups' perspectives, concerns, and preferences are embedded in educational systems, which clearly disadvantage students from groups who are non-dominant (and often marginalized or excluded) (Garibay & Teasdale, 2019). During this 4-hour workshop, facilitators will focus on sharing our recently created guidelines for conducting high-quality, equity-enabling education research. The guidelines have been developed by a team of researchers with diverse backgrounds who studied education research evidence standards across several countries and conducted a deep-dive into how to produce education research that honors and includes various groups of learners (McGill, Heckman, Chytas, Liut, Kazakova,

Sanusi, Shah, & Szabo, 2023). This workshop is for any researcher currently studying science education who wants to learn more about characteristics of high-quality education research, how to conduct research that meets these characteristics, and how to center the participants and their lived experiences throughout the research process. Participants will learn about the guidelines and associated resources, discuss their application to current or proposed research projects, and gain a new appreciation for how to embed equity perspectives in each phase of their research. Specifically, participants will reflect upon how their personal positionalities impact their research. They will also improve their ability to use an equity lens when writing research questions, use theoretical frameworks, and develop instrumental and protocols.

Research Committee
Pre-Conference Workshop
Using the Science and Engineering Practices Observation Protocol (SciEPOP) to Identify Children's Engagement with Science and Engineering in Early Learning Environments
17-Mar-24, 8:00 AM-11:45 AM
Location: Governor's Square 17

Using the Science and Engineering Practices Observation Protocol (SciEPOP) to Identify Children's Engagement with Science and Engineering in Early Learning Environments

ORGANIZERS
Alison Miller, Bowdoin College, Brunswick, ME, USA

PANELISTS
Alison Miller, Bowdoin College, USA
Laura Saenz, Bowdoin College, USA
Hildah Makori, Bowdoin College, USA
Katahdin Cook, Maine Mathematics and Science Alliance, USA
Lisa Kenyon, Maine Mathematics and Science Alliance, USA
Rachel Larimore, Samara Early Learning, USA

ABSTRACT
In recent years, the Framework and NGSS have sparked renewed interest in nurturing science and engineering learning in early childhood settings. It is widely accepted that children learn through play and previous work has highlighted how young children naturally engage in science and engineering in their play. The Science and Engineering Practices Observation Protocol (SciEPOP) was designed to allow researchers to identify play-based engagement with science and engineering practices (SEPs) and categorize the range of these engagements. The SciEPOP also provides information about the physical environment, including available materials, and educator moves that support children's engagement with SEPs. The SciEPOP is currently being used in research and educator professional learning to support educators in noticing and extending children's natural engagement with SEPs for

more frequent and meaningful engagement with science. In this workshop, researchers and practitioners will be introduced to the SciEPOP and gain practice using the tool with video-based cases. Participants will discuss effective strategies to support children's science learning in both formal (preschool/early elementary) and informal (out-of-school) environments. Participants will envision future uses for the SciEPOP in their own research or practice context. Workshop goals are: (1) Gain familiarity with the Science and Engineering Practices Observation Protocol (SciEPOP) and its use in early learning environments; (2) Practice using the SciEPOP with video-based cases; (3) Discuss effective strategies to support children's science learning in the early years; (4) Envision future uses of the SciEPOP.

Committee Meeting
NARST Board of Directors Meeting
17-Mar-24, 8:00 AM-11:45 AM
Location: Directors Row E

Research Committee
Pre-Conference Workshop
Integrating ChatGPT in Science Teacher Education and Science Education Research: Improving Curriculum, Pedagogy, Research and Equity in Science
17-Mar-24, 8:00 AM-11:45 AM
Location: Plaza Court 1

Integrating ChatGPT in Science Teacher Education and Science Education Research: Improving Curriculum, Pedagogy, Research and Equity in Science

ORGANIZERS
Mehmet Aydeniz, The University of Tennessee, Knoxville, USA
Michael Stone, Public Education Foundation, Chattanooga, TN, USA

PANELISTS
Mehmet Aydeniz, The University of Tennessee, Knoxville, USA
Michael Stone, Public Education Foundation, Chattanooga, TN, USA

ABSTRACT
This workshop aims to equip science teacher educators and graduate students with the knowledge and skills to effectively utilize ChatGPT, a large language model to prepare future science teachers and design creative and relevant research projects in science education that promote equitable learning opportunities and culturally responsive pedagogies. Participants will explore various applications of ChatGPT for teacher educators and research, gain hands-on experience in developing AI-enhanced teaching resources and designing research projects. In addition to hands-on activities, the workshop will engage attendees in discussions around the ethical and responsible use of chatGPT, how AI maybe used to

increase impactful learning opportunities for underserved and under-resourced students through group work. Finally, the workshop aims to form a community of practice around the use of GENAI tools in science teacher preparation and science education research.

Research Committee
Pre-Conference Workshop
Using Network Analysis to Analyze Scientific Knowledge Structures and Transition Data
17-Mar-24, 8:00 AM-11:45 AM
Location: Plaza Court 3

Using Network Analysis to Analyze Scientific Knowledge Structures and Transition Data

ORGANIZER
Jennifer Cromley, University of Illinois, USA

ABSTRACT
Learners often develop fragmented knowledge in science and can navigate learning spaces in fragmented ways. This hands-on workshop will show you how to apply free R software packages to apply network analysis techniques to knowledge and navigation data. Brief presentations will demonstrate each step in preparing verbal (e.g., interview, think-aloud, written answers, concept maps) or transition (e.g., eye tracking, computer log files, turn taking) data for network analysis. Each network approach (metric) will be modeled with real science education data and all R code will be supplied, together with access to online resources to use after the workshop. Multiple decision points in applying network analysis will be discussed, such as different types of weights, which network analysis metrics to use, positively- and negatively-valenced data, working with multiple types of data simultaneously, and doing further analysis of network analysis metrics using other data in hand. Participants are encouraged to bring a dataset to the workshop, but this is not required. No prior experience with network analysis or R is expected, but directions will be sent prior to the workshop for downloading the free software before the workshop begins.

Research Committee
Pre-Conference Workshop
Broader Impacts-Driven Dissemination: Benefiting Society Beyond Presentations and Publications
17-Mar-24, 8:00 AM-11:45 AM
Location: Plaza Court 4

Broader Impacts-Driven Dissemination: Benefiting Society Beyond Presentations and Publications

ORGANIZERS
Deborah Hanuscin, Western Washington University, USA
Natalie King, Georgia State University, USA
G. Michael Bowen, Mount St Vincent University, Canada

PANELISTS
Deborah Hanuscin, Western Washington University, USA

ABSTRACT
Dissemination is a key component to any successful research and development project. In our experience serving on NSF review panels, we note that dissemination plans typically involve the "usual suspects" of publishing in peer-reviewed journals and presenting at professional conferences. Rarely are dissemination plans conceptualized as assisting projects in achieving their broader potential impacts. We believe this to be a missed opportunity. In working on our own federally-funded projects, we have developed an approach we refer to as "Broader-Impacts Driven Dissemination". In this workshop, we will share this approach with the goals of:
1. Strengthening researchers' understanding of the NSF Broader Impacts criterion
2. Assisting researchers in developing dissemination plans that can contribute to achieving their intended Broader Impacts
Researchers of all stages are encouraged to join this session to develop their own BI-Driven Dissemination plans.

Research Committee
Pre-Conference Workshop
Using Novel Instructional Materials to Improve Students' Mis/disinformation Detection and Socioscientific Decision-making
17-Mar-24, 8:00 AM-11:45 AM
Location: Plaza Court 5

Using Novel Instructional Materials to Improve Students' Mis/disinformation Detection and Socioscientific Decision-making

ORGANIZERS
Benjamin Herman, Texas A&M University, USA

PANELISTS
Benjamin Herman, Texas A&M University, USA
Michael Clough, Texas A&M University, USA
Sarah Poor, Texas A&M University, USA
Ben Janney, Texas A&M University, USA
Asha Rao, Texas A&M University, USA
Tamara Powers, Texas A&M University, USA
Joanna Goodey Pellois, Texas A&M University, USA

ABSTRACT
This workshop presents the efforts of an NSF-funded research project: "Using Novel Instructional Materials to Improve Students' Detection of Pseudoscience in Decision-Making about Socially-relevant Real-World Issues" (Award No. 2111199). Through this project, the presenters have developed, implemented, and researched the implementation of highly impactful instructional materials that focus on mis/disinformation associated with socioscientific issues (SSI, e.g., climate change, biological racism). The instructional materials include historical stories and case studies that: (a) make overt the features of science mis/disinformation and their harmful impacts on SSI decision-making; (b) promote accurate science content and nature of science (NOS) understanding related to the SSI; (c) foster trust in the scientific community; and (d) improve future mis/disinformation detection and SSI decision-making.
This workshop will include interactive sessions that: 1) address how to develop historically accurate and socioculturally sensitive instructional materials that make evident science mis/disinformation for teachers and students of science at multiple levels (e.g., preservice teachers, college science students and teachers); 2) model highly effective research-based instructional practices (e.g., inquiry practices, case study implementation) using the project materials; 3) present the research outcomes associated with the project; and 4) discuss with workshop attendees perspectives regarding the materials and the possibility of future collaborations to include additional materials development and research.

Research Committee
Pre-Conference Workshop
How to Use AI and Center People in Science Education Research
17-Mar-24, 8:00 AM-11:45 AM
Location: Plaza Court 6

How to Use AI and Center People in Science Education Research

ORGANIZERS
Marcus Kubsch, Freie Universität Berlin, Germany

PANELISTS
Marcus Kubsch, Freie Universität Berlin, Germany
Kristina Krist, University of Illinois Urbana-Champaign, USA
Peter Wulff, Heidelberg University of Education, Germany
Joshua Rosenberg, University of Tennessee, Knoxville, USA
Kevin Hall, University of Illinois Urbana- Champaign, USA
Eugene Cox, University of Illinois Urbana-Champaign, USA
Chris Palaguachi, University of Illinois Urbana-Champaign, USA
Paul Tschisgale, IPN – Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
As the recent discussion in the Journal of Research in Science Teaching shows, a vivid discussion about when, how, and why to use artificial intelligence (AI) in science education (research) is currently taking place in the NARST community. More broadly, the potentials, challenges, and even dangers of AI are negotiated in the education community and society at large. In these discussions, we often see (exaggerated) praise for how AI will revolutionize science education and similarly (potentially) exaggerated warnings about how AI will doom us. To participate actively, critically, and productively in these discussions, members of the NARST community need to learn about the technological and political dimensions of AI. In this workshop, we aim at providing NARST members with a foundational understanding of and self-efficacy regarding AI so that they can effectively learn more about AI and are positioned to ask critical questions when confronted with AI in the context of science education (research). As AI is an often intimidating topic, we – in correspondence with the conference theme – want to empower NARST to become agentic with respect to AI. Thus, the workshop includes practical parts in which we lift the veil around AI when participants take a look under the hood of machine learning (ML) – a foundational AI technique – and apply it themselves. In this spirit, the workshop will also provide rich networking opportunities so that participants can build connections that support them as they engage more with AI.

International Journal of Science Education
Pre-Conference Workshop
Publishing in Science Education Journals and Tips to Help You Succeed
17-Mar-24, 10:00 AM-11:45 AM
Location: Plaza Court 2

Publishing in Science Education Journals and Tips to Help You Succeed

ORGANIZERS
Ron Blonder, Weizman Institute, Israel
M. Gail Jones, North Carolina State University, USA

PANELISTS
Ron Blonder, Weizman Institute, Israel
M. Gail Jones, North Carolina State University, USA
Vanessa Kind, University of Leeds, United Kingdom

ABSTRACT
This workshop is designed to provide participants with a generic and basic introduction to the process of manuscript preparation and peer review, right through to publication, with specific reference to science education research journals. The session is designed for new scholars who may want to learn more about the process and how to improve their publication success. Some of the latest developments in journals publishing will also be covered. The workshop will be conducted in two parts. The first part will be a presentation

from Taylor & Francis' Science Education Journal Editors. During this segment, tips for publishing, strategies for improving citation rates and information about journal indices will be shared. The second part will comprise a panel discussion where attendees will be able to quiz the Editors of Taylor & Francis' science education journals about the process of publication in their journals. Finally, editors will be available to workshop participants for individual discussions about the best places to publish specific manuscripts.

Graduate Student Committee
Social Event
Graduate Student Luncheon
17-Mar-24, 11:45 AM-1:00 PM
Location: Governor's Square 15

Graduate Student Luncheon

ORGANIZER
Jennifer Bateman, Clemson University, USA

Plenary Session
Presidential Welcome
17-Mar-24, 1:00 PM-1:30 PM
Location: Plaza Ballroom ABC/DEF

Keynote Address
Monsanto's Past and Our Food Future: Considerations for Science Education
17-Mar-24, 1:30 PM-2:45 PM
Location: Plaza Ballroom ABC/DEF

Monsanto's Past and Our Food Future: Considerations for Science Education
Bartow Elmore*, The Ohio State University, USA

ABSTRACT
Dr. Bartow Elmore is an award-winning professor and core faculty member of the Sustainability Institute at Ohio State University, as well as a writer who investigates the impact of big business on our environment.

He is also the award-winning author of two books, Citizen Coke: The Making of Coca-Cola Capitalism (W. W. Norton, 2015) and Seed Money: Monsanto's Past and Our Food Future (W. W. Norton, 2021). He currently edits the Histories of Capitalism and the Environment book series at West Virginia University Press.

Bartow received his B.A. in History from Dartmouth College and his M.A. and Ph.D. from the University of Virginia. He currently resides in Columbus, Ohio with his wife, Joya, and their two sons, River and Blue. For fun, he loves whitewater kayaking, mountain biking, backpacking, basketball, and mixing digital beats.

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set
Learning Progression and Disciplinary Core Ideas
17-Mar-24, 3:00 PM-4:30 PM
Location: Plaza Court 2

Learning Progression of Students' Reasoning about Life Cycles
Hayat Hokayem*, Texas Christian University, USA
Ihsan Ghazal*, Texas Christian University, USA
Savannah Graham*, University of Houston, USA

ABSTRACT
This study uses the learning progression approach to tease apart student reasoning about life cycles, and compare their pre/post reasoning when using an inquiry unit to learning about life cycles. The participants were 24 fifth graders who learned science in English in a private school in Beirut, Lebanon. The data sources consisted of pre/post structural interviews, pre/post written assessment, video-taping all the classrooms lessons of the life cycle unit, and the investigator's classroom notes. The results showed that while none of the students recognized the cyclical nature of the life cycle in the pre-test, 16 students out of 24 recognized it in the post-test. Moreover the results revealed four levels of reasoning concerning the comparison of the different life cycles: the first recognizing only behavioral changes, the second recognizing the number of stages and some description of some of the stages, and the third recognizing the major changes in the life cycle such as complete and incomplete metamorphosis, and the fourth recognizing the similarities and differences between life cycles at every stage. We discuss the implications of those results for curriculum and instruction.

Students' Ideas About Air Pollution: A Learning Progression for the Primary and Secondary School
Èlia Tena*, Universitat Autònoma de Barcelona (UAB), Spain
Caterina Solé, Universitat Autònoma de Barcelona (UAB), Spain
Digna Couso, Universitat Autònoma de Barcelona (UAB), Spain

ABSTRACT
Air pollution caused by pollutant gases and particulate matter is one of the challenges of our era and a relevant topic for science education. However, what the students' ideas about the nature and the structure of air pollution are and how they could progress along primary and secondary education is a topic scarcely researched. In this communication, we aim to analyze 10 to 15-year-old students' ideas about air pollution to develop an empirically tested learning

progression about air pollution. Our research shows that there are common barriers across ages, such as the difficulty to overcome the idea of polluted air as composed by different components and gases. Also, that there are necessary milestones, such as a semicontinuous conception of air. These results have helped us to develop teaching and learning strategies to support the students' progression.

Extracting Student Mastery of Force and Motion Attributes Using Cognitive Diagnosis Model

Maria Veronica Torralba*, De La Salle University, Philippines
Talaue T., De La Salle University, Philippines

ABSTRACT

This study analyzed student responses to a standardized exam In physics administered to a local secondary school using a cognitive diagnosis model (CDM). Multiple choice exam items on force and motion were examined in terms of the following attributes: identifying all forces acting on an object, decomposing a force vector into components, performing vector summation of forces, conceptually describing the effects of balanced and unbalanced forces on an object, and applying Newton's second law of motion. While the exam items are multi-dimensional in nature, requiring more than one attribute of force and motion, information regarding each attribute was extracted using CDM analysis. Specifically, the probability of mastering each attribute was obtained as well as the attribute mastery patterns of the students. Possible learning trajectories were inferred using an inclusion principle and the relative dominance of the mastery patterns. Information on attribute mastery patterns can be used in designing customized intervention for students while the possible learning trajectories can potentially provide insights in designing teaching-learning sequences.

Developing a Three-Dimensional Learning Progression for the Thermal Energy at Middle School Science

Mao-Ren Zeng*, Michigan State University CREATE for STEM Institute, USA
He Peng*, Michigan State University CREATE for STEM Institute, USA
Mingchun Huang, Michigan State University CREATE for STEM Institute, USA
Namsoo Shin, Michigan State University CREATE for STEM Institute, USA
Jonathan Bowers, Michigan State University, USA
Joseph Krajcik, Michigan State University CREATE for STEM Institute, USA

ABSTRACT

Substantial learning progression (LP) research has provided the empirical foundation for depicting students' learning process toward knowledge-in-use in science. According to Next Generation of Science Standards, knowledge-in-use refers to students applying disciplinary core ideas, science and engineering practices, and crosscutting concepts to make sense of compelling phenomena or solve complex problems. As such, LPs should integrate the disciplinary core ideas, science and engineering practices, and crosscutting concepts to map out student knowledge-in-use development. However, most research developed learning progressions focus on disciplinary core ideas, science and engineering practices, or crosscutting concepts rather than creating a three-dimensional LP (3DLP) to support student knowledge-in-use. This study aims to develop the 3DLP aligned with learning theories to support students in developing usable knowledge. We used design-based research approach to develop our 3DLP through an iterative process and conducted the student interviews. Results of this study showed that the students' understanding of thermal energy, developing and using models, and systems and system models. To conclude, this study illustrates the development of an evidence-based 3DLP of the thermal energy and provides new insight for integrating the three-dimensions in classroom instruction and assessment to prompting student learning.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
Technology: Programming and Computational Thinking
17-Mar-24, 3:00 PM-4:30 PM
Location: Plaza Court 4

Current Research Trends of Computational Thinking in the Context of STEM Education
Yurdagül Bogar*, Oslo Metropolitan University, Norway
Jari Lavonen, University of Helsinki, Finland

ABSTRACT
The purpose of the study is to conduct a meta-synthesis on computational thinking in the context of STEM education and to determine the research trends in this field. To achieve this goal, meta-synthesis was employed in this study. Our meta-synthesis study consists of some inclusion and exclusion criteria. Moreover, the selection process of the articles to be included in this research was carried out in two separate stages. As a result, 39 articles were included in this study. Articles included in the meta-synthesis research have been analyzed in terms of implementation country of the study, publication year, name of the journal, article type, and method. The findings of this meta-synthesis study indicated that the studies on computational thinking in the context of STEM have significantly increased in the last few years (2020, 2021, 2022) compared to other years. Based on this, we can conclude that researchers' interest in computational thinking in the context of STEM has gained popularity. Therefore, the results obtained from this meta-synthesis study will make a great contribution to researchers interested in science education, STEM education, and also computer science education.

Promoting Meaningful Learning of Programming Language: Should we trust CTCA?
Esther Peter*, Lagos State University, Nigeria
Peter Okebukola, Lagos State University, Nigeria
Juma Shabani, Université du Burundi, Burundi
David Peter, Lagos State University, Nigeria
Deborah Agbanimu, Lagos State University, Nigeria

ABSTRACT
In the rapidly evolving landscape of education, the teaching and learning of programming languages have become paramount in preparing students for a technology-driven world.

This article delves into the potency of culturo-techno-contextual approach (CTCA) in facilitating a more profound and comprehensive grasp of programming languages. The study adopted an explanatory sequential mixed method whereby quantitative and qualitative data were gathered. The sample was drawn from two senior secondary schools offering ICT in Lagos, Nigeria. The experimental class had 24 respondents (15 boys, 9 girls) while the control class had 23 respondents (10 boys, 13 girls) senior secondary school 1 computer studies students. Quantitative data were collected through the programming language achievement test with respectable instrument measures including a reliability value of 0.71. Students in the experimental group were taught programming language using CTCA. The control class had the same learning experience as the experimental class-exclusive of the elements of CTCA. Analysis of covariance results showed that there is a statistically significant difference in the achievement of students taught programming language using CTCA and lecture method, $F(1, 46) = 21.84; p<.05$. The results showed that CTCA has proven to be effective in promoting meaningful learning of computer studies.

STEM Activities Integrated with Computational Thinking (CT): Early Childhood Children' CT Skills

Nazlı Ülker Hançer, Sinop University, Turkey
Mustafa Topçu*, Yıldız Teknik University, Turkey

The aim of this study is to determine the effect of the STEM activities integrated with CT on early childhood children's CT skills (representation and control structures). A total of 6 early childhood children participated in the study. The study was designed as a one-group pretestposttest experimental design. STEM activities integrated with CT prepared for the subdimensions of representation and control structures of CT were carried out with the study group. As a data collection tool, the measurement tool developed by Relkin and Bers (2021) to measure the CT skills of early childhood children and adapted into Turkish by Authors (2021) was used. The data were analyzed with the Wilcoxon test, which is a non-parametric test. As a result of the analysis, it was observed that there was a significant difference between the pre-test and post-test scores obtained from both the representation and control structures sub-dimensions, and this difference was in favor of the post-test score. Considering this difference, it is possible to say that STEM activities integrated with CT have a positive effect on the development of representation and control structures sub-dimensions of CT in early childhood children.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

SC-Organized Paper Set

Elementary STEM Integration

17-Mar-24, 3:00 PM-4:30 PM

Location: Plaza Court 3

Integrated STEM in Elementary Schools: Critical Aspects to Consider

Carol Waters*, University of Houston-Clear Lake, USA

ABSTRACT
Creating a STEM-literate populous should begin with students' early exposure to integrated STEM concepts, including 21st-century skills, engineering habits of mind, and engineering design practices. This study examined how STEM was integrated into an elementary-level school. The survey, interview, focus group, and observational data were collected, analyzed, and coded to determine critical aspects of integrating a STEM program into an elementary school. Findings include the specialist's critical role, the importance of instructional design, and the integration of the engineering laboratory. The results of this study point to the need to increase the number of integrative STEM programs that promote the empowerment of teachers to design STEM curricula and embrace effective engineering design practices in elementary schools.

"This is My Best STEM Class": Practicing STEM from Educators with Different Professional Experiences

Qiu Zhong*, Indiana University Bloomington, USA
Conghui Liu*, Indiana University Bloomington, USA
Adam Maltese, Indiana University Bloomington, USA

ABSTRACT
This qualitative multiple case study explored three elementary educators with different professional experiences: a science teacher, a STEM school principal, a district STEM superintendent about their understandings and practices in STEM. For each educator, data includes two interview voice recordings and a representative STEM class video and/or lesson plans that were selected by the educator. The results indicated that they have similar understandings of STEM education with the same key words been identified: integration, interdisciplinary, problem solving and real-life scenarios. However, they showed very different STEM practices that most suitable in their school contexts that all highlighted the core of STEM- integration. With different professional roles and contexts, the three educators see students' needs from different perspectives, and draw different resources to address those needs through different STEM activities. By providing the three educators' stories of exploring STEM, this study highlights how the context-rich, place-based, flexible, sensitive nature of STEM reflected in real classes. We expect this study can initiate a discussion for other STEM practitioners, to share their understandings and practices in STEM under their culture and local contexts. We hope such dialogues enrich and broaden the meaning of STEM education.

Community-Based Engineering Education in Elementary Schools: A Multi-Case Study in Rural Communities

Tugba Boz*, Purdue University, USA
Rebekah Hammack*, Purdue University, USA
Nicholas Lux, Montana State University, USA
Paul Gannon, Montana State University, USA

ABSTRACT
This study emphasizes the integration of place-based learning within community-based engineering lessons and providing meaningful engineering learning experiences for students from diverse backgrounds. By leveraging the unique knowledge of students and their communities, teachers can enhance students' development of engineering identity and help students view engineering as a potential career option. In this paper, we examined the effects of our participant teachers' community-based engineering lessons on their students' attitudes and perceptions toward engineering. We also employed teacher interviews to investigate teachers' perspectives about their teaching and their students' learning of engineering. The findings revealed a significant increase in students' occupational identity scores in total and across different school contexts (reservation/rural vs small town/rural) after students were exposed to community-based engineering lessons. The interaction between time and context was also significant in students' perceptions of academic identity, occupational identity, engineering aspirations, and their attitudes toward engineering and technology. It is notable that reservation areas showed consistent growth across these variables. The teacher interviews reinforced this trend and highlighted that community-based engineering lessons enhanced their students' engineering identity. Teachers recognized the importance of connecting lessons with place in rural communities and, particularly history and culture in reservation areas.

Discourse and Creativity in Early Childhood Engineering
Mia Williams*, University of Wyoming, USA
Alison Mercier*, University of Wyoming, USA

ABSTRACT
Young children are deeply curious about the world around them and ambitiously creative when considering real-world problems and solutions. Engaging young learners in engineering takes advantage of this innate interest and provides them with authentic opportunities to engage in collaborative, creative, problem solving. Discourse is a cornerstone of these experiences. Therefore, we explored the nature of students' discourse during collaborative engineering challenges created with an early childhood setting in mind. This qualitative study utilized assessments of children's creativity in designing real-world solutions and discourse analysis of peer-to-peer problem-solving. We outline features of young children's creativity and highlight connected patterns of problem-solving discourse.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

SC-Organized Paper Set

Modelling Curriculum for Learning

17-Mar-24, 3:00 PM-4:30 PM
Location: Plaza Court 5

"Fail Faster": How a Teacher Supported Students With Testing and Debugging Computational Models

Jonathan Bowers*, Michigan State University, USA
Emil Eidin, Michigan State University, USA

ABSTRACT
Testing and debugging is increasingly recognized as a key aspect of computational thinking and computational modeling and a major learning goal for STEM education. Further efforts are needed to understand how teachers can support students with key testing and debugging behaviors during computational modeling, including analyzing model output, analyzing and using external data to verify model behaviors, and using peer feedback. In this study we investigated a teacher's pedagogical strategies for supporting students with testing and debugging in a unit that required computational modeling. Through analysis, we identified key demonstrations, informational talks, and small group conversations that the teacher used to provide students both a rationale and procedure for various aspects of testing and debugging. The teacher's talks on strategies and rationales for students analyzing model output and using peer feedback represent an important finding with implications for practitioners and curriculum designers. Overall, this study provides insights into the teacher strategies needed to support students in using different aspects of testing debugging within a computational modeling context.

How Can Science Teacher's Discourse Be Like?: Discursive Strategies in a Modelling-Based Classroom

Camilo Vergara-Sandoval*, Universidad de O'Higgins, Chile
Víctor López*, Universitat Autònoma de Barcelona, Spain
Digna Couso*, Universitat Auònoma de Barcelona, Spain

ABSTRACT
With the intention of knowing how to promote modelling in the science classroom, this research identified discursive strategies that teachers usually use to encourage student participation in this scientific practice while participating in a science workshop. A discourse analysis methodology was used to characterise teachers' discursive actions as communicative acts, the modelling practices in which teacher and students participate during discussions, and the sequences of modelling practices as they occur in a science classroom. In addition, through different examples of discussions between students and teachers, the functions of the articulations of communicative acts were discussed according to how they mediated the development of students' ideas and their participation in modelling practices. Thus, four types of articulation of discursive actions were identified that usually guide the teachers' discourse when they want the students to participate in sequences of modelling practices that encourage the expression, questioning, review and consensus of ideas. The identification of this type of discursive strategies allows teachers to approach a set of tools at the service of teachers to, in a certain way, plan instances of evaluation of the ideas of the students that arise spontaneously in dialogues with teachers, and to encourage their participation in modelling practices.

Integrating a New Computational Modeling Curriculum Into High School Science Classrooms

Jacqueline DeLisi*, Education Development Center, USA
Beatriz Perret, Education Development Center, USA
Suhina Minocha, Education Development Center, USA
Irene Lee, Education Development Center, USA
Kirsten Peterson, Education Development Center, USA

ABSTRACT

There is a need to expose all students to modern scientific practices and sense-making in science (Schwarz, Passmore & Reiser, 2017). Yet, teachers are challenged to introduce scientific experiences that reflect those of practicing scientists, including computational thinking and modeling. Further, only about half of US high schools offer computer science courses, limiting access to CS/CT, especially for students from minoritized communities. New approaches are needed. This paper describes a new set of high school units designed to embed CS/CT into traditional high school science courses and explores teachers' implementation of the materials. Analysis of teacher surveys, interviews, focus groups, and observations highlights successes and challenges, and provides examples of how teachers can embed CS/CT to enable all students to access key science concepts through using, decoding, and modifying computer models and simulations.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Graduate Students in STEM Education
17-Mar-24, 3:00 PM-4:30 PM
Location: Plaza Court 6

International Graduate Students as STEM Role Models for High School Students

Ana-Maria Topliceanu*, North Carolina State University, USA
Katherine McCance, University of Texas at San Antonio, USA
Jennifer Sollinger, North Carolina State University, USA
Margaret Blanchard, North Carolina State University, USA

ABSTRACT

This pilot study investigated the factors international graduate students in STEM programs most considered and the challenges, supports, and benefits they perceived when planning and implementing Zoom visits to high school classrooms. The Motivational Theory of Role Modeling guided the interpretation in this exploratory, qualitative study of how international graduate STEM students acted as role models for high school students when planning and implementing these visits. Interviews were conducted with five international graduate STEM students from three research universities (two public, one private) who were involved in a shared NSF-funded research grant. The interview data were analyzed using the constant comparative method. The findings indicated that, when acting as role models, these graduate students most considered: the relevance of science, job opportunities in STEM

fields, and engaging students. The international graduate students perceived challenges associated with how to make the complex academic language and research understandable to high school students and their English skills, and received support from university team members as well as the high school teachers. Implications for formalized training of the international graduate STEM students are discussed.

The Impact of Teaching Professional Development on STEM Graduate Student Teaching Outcomes: A Meta-Analysis

Grant Gardner*, Middle Tennessee State University, USA
Alyssa Freeman, Middle Tennessee State University, USA
Chelsea Rolle, Middle Tennessee State University, USA
Kadence Riggs, Middle Tennessee State University, USA

ABSTRACT

The adequacy of training programs to prepare STEM graduate teaching assistants (GTAs) for a diverse workforce has recently been challenged. These training programs rarely include Teaching Professional Development (TPD) for graduate students. However, we have very little research-based and rigorous evidence as to whether and how TPD for STEM graduate students impacts critical outcomes. Utilizing an established evaluation framework for STEM graduate student TPD outcomes we sought to answer the following research question: What is the impact of teaching professional development on STEM graduate students' cognitive outcomes, practice outcomes, and undergraduate student learning outcomes? A meta-analysis was conducted on a sample of n = 29 papers. Papers were selected via a PRISMA protocol with appropriate exclusion and inclusion criteria. Findings indicate a statistically significant positive effect of TPD on graduate students' teaching self-efficacy and knowledge/beliefs about instruction as well as a negative effect of TPD on undergraduate students' perceptions of graduate students teaching practices. The meta-analysis supports calls for a more cohesive exploration of the impacts of teaching professional development on graduate student outcomes and the learning outcomes of the students they teach.

The Relationship of Graduate Teaching Assistants' Perceived Autonomy with Their Pedagogical Discontentment, Self-Efficacy, and Practices

Alyssa Freeman*, Middle Tennessee State University, USA
Grant Gardner, Middle Tennessee State University, USA
Chelsea Rolle, Middle Tennessee State University, USA
Kadence Riggs, Middle Tennessee State University, USA
Georgia Sroka, Middle Tennessee State University, USA
Tom Brinthaupt, Middle Tennessee State University, USA

ABSTRACT

More than half of STEM graduate teaching assistants (GTAs) will enter future careers with teaching workloads. However, little is known about many instructional-related outcomes for STEM GTAs when exposed to teaching professional development (TPD). At a large public institution in the Southeastern United States, a semester-long TPD was offered to GTAs across the University. A pre-post quasi-experimental research design was used to survey data

to evaluate GTA pedagogical discontentment, self-efficacy, autonomy, and instructional practices. There were 141 participants over the six years of the program. We ran t-tests to analyze outcome differences between STEM and non-STEM GTAs and between the pre- and post-survey data. There were no statistical differences found in outcomes between STEM and non-STEM GTAs. While the changes in the constructs were small, there were statistically significant decreases in GTAs' pedagogical discontentment and increases in self-efficacy. Most GTAs reported having no or some autonomy in their teaching. GTAs reported increases in their use of student-centered practices. However, approximately half of the GTAs indicated they are not using student-centered teaching practices even after the TPD program. These data highlight important themes in the TPD literature regarding the inter-relationships of pedagogical discontentment, self-efficacy, and autonomy in promoting instructional change.

Empowering Graduate Teaching Assistants in STEM: Role of Collaborative Action Research in Professional Agency Development

Abdul Rauf*, University of Illinois Chicago, USA
Minjung Ryu, University of Illinois Chicago, USA

ABSTRACT

Collaborative Action Research (CAR) has been extensively used as a professional development strategy. However, there are limited studies that explore CAR within the domain of university-based instruction, leaving a notable gap in the examination of the distinctive collaborative and partnership dynamics intrinsic to CAR in such settings. Within the broader framework of professional development, the relevance of CAR becomes more pronounced in case of graduate Teaching Assistants (TAs). TAs, pivotal in college STEM education are often considered "cheap labor" with little regard for their agency and professional growth- Park and Ramos (2002) described TAs experience as "donkey in the department", highlighting the disproportionate balance between heavy workload and limited autonomy. The issues related to CAR in university settings, especially when it involves graduate TAs, call for a nuanced exploration into power dynamics and agency-related complexities. Our study investigates the role of CAR in fostering the professional agency of graduate Teaching Assistant (TAs). Findings indicate that CAR fosters intrinsic agency, collaboration, decision-making autonomy, and reflective introspection in TAs. Consequently, TAs perceive themselves as pivotal stakeholders and engage as empowered, strategic contributors in the academic process. This research underscores CAR's potential to reshape the professional development landscape for TAs in higher education.

Strand 6: Science Learning in Informal Contexts

Related Paper Set

Engaging Rural and Tribal Communities in Culturally Responsive Research and Evaluation on Informal Science Learning

17-Mar-24, 3:00 PM-4:30 PM

Location: Governor's Square 10

Indigenous Logic Model Development: Fostering Collaborative Engagement and Cultural Relevance

Anne Gold*, University of Colorado, USA
Nancy Maryboy, Indigenous Education Institute, USA
David Begay, Indigenous Education Institute, USA
Shelly Valdez, Native Pathways, USA
Jill Stein, Reimagine Research Group, USA
Megan Littrell, University of Colorado, USA
Kathryn Boyd, University of Colorado, USA
Christine Okochi, University of Colorado, USA
Brigitta Rongstad Strong, University of Colorado, USA

ABSTRACT
Indigenous logic models offer a culturally grounded and community-driven approach to program development and evaluation and are designed to foster continuous learning and growth. This paper examines the development of a logic model inspired by Indigenous evaluation approaches for the [Program Name], a water-themed traveling library exhibition centered on community resilience against climate change impacts in the US desert Southwest. The program's logic model is based on the life cycle of a yucca plant, a symbol of resilience and adaptation and an iconic plant of the region. It features iterative cycles of reflection, integration, and growth, emphasizing community relationships and holistic evaluation. The yucca plant logic model is used for ongoing reflection, adaptation, and growth and incorporates community perspectives and needs, ensuring the project remains responsive to changing circumstances. Further studies could explore the impact of partnership-based logic models on research processes, relationships, and project outcomes.

Engaging Library Visitors in Dialogues around Informal Learning about Water and Community Connections

Megan Littrell*, Cooperative Institute for Research in Environmental Sciences Education and Outreach, USA
Christine Okochi, Cooperative Institute for Research in Environmental Sciences Education and Outreach, USA
Kathryn Boyd, Cooperative Institute for Research in Environmental Sciences Education and Outreach, USA
Anne Gold, Cooperative Institute for Research in Environmental Sciences Education and Outreach, USA
Daniela Pennycook, Cooperative Institute for Research in Environmental Sciences Education and Outreach, USA
Mia McCormick, Cooperative Institute for Research in Environmental Sciences Education and Outreach, USA
August Mrakuzic, Cooperative Institute for Research in Environmental Sciences Education and Outreach, USA

ABSTRACT
The exhibition travels to rural and Tribal libraries in the Four Corners region of the Southwestern United States. This research study aimed to understand how the exhibition contributed to informal learning about science and multiple ways of knowing about water. The research was initially guided by STEM Learning Ecosystems, Sociocultural Learning Theory, and Place-based learning theories, recognizing the role of social and cultural experiences, and place in shaping science learning. The paper describes adaptations made to research approaches to be culturally responsive and improve community involvement. This included inviting local student research assistants at each site to engage library visitors in recorded Talk Story dialogues about water in their communities and their experiences with the exhibition. Themes emerged from these conversations around multi-generational learning, community connections and disagreements about water, and the exhibit's impact on visitor engagement. Visitors expressed pride in hosting the exhibition and personal inspiration to continue learning and communicating with community members about water topics. The study showcases the successful adaptation of research methods to encourage visitor participation and foster meaningful conversations and informal science learning about water-related topics within and across rural and Tribal communities.

Colorado Science Education Research

Water Meaning Maps: Diving Deeper Into Rural Library Visitors' Connections With Water in the Southwest

Christine Okochi*, CIRES, University of Colorado Boulder, USA
Megan Littrell, CIRES, University of Colorado Boulder, USA
Kathryn Boyd, CIRES, University of Colorado Boulder, USA
Anne Gold, CIRES, University of Colorado Boulder, USA

ABSTRACT
We Are Water is an exhibition traveling to rural and Tribal libraries in the Four Corners Region of the Southwestern United States to engage multi-generational audiences in exploring the science and cultural aspects of water in the region. Evaluation of the project adapted methods used in informal settings to better suit the rural and Tribal library context and audience. Here we describe water meaning maps, inspired by Personal Meaning Maps, as a tool to better understand library visitors' experiences with the exhibition. The water meaning map activity prompted library visitors to express what water means in their communities through drawing or writing, followed by optional discussion with project staff. A total of 68 visitors at three library sites participated in the activity during community events, such as the exhibition opening day celebration or youth events. The content of the meaning maps reflected the four exhibit themes, grounding these themes within visitors' local communities and inspiring intergenerational conversations about their experiences with water. Here we discuss challenges encountered during implementation and adaptations made to using water meaning maps in the evaluation of the exhibition. Ultimately, the water meaning maps proved to be an effective and accessible evaluation tool in this context.

Engaging Communities and Adapting Informal Learning Research and Evaluation Methods to Rural Library Settings

Kathryn Boyd*, Cooperative Institute for Research in Environmental Sciences Education & Outreach, USA
Megan Littrell, Cooperative Institute for Research in Environmental Sciences Education & Outreach, USA
Christine Okochi, Cooperative Institute for Research in Environmental Sciences Education & Outreach, USA
Jill Stein, Reimagine Research Group, USA
Shelly Valdez, Native Pathways, USA
Anne Gold, Cooperative Institute for Research in Environmental Sciences Education & Outreach, USA
Brigitta Rongstad Strong, Cooperative Institute for Research in Environmental Sciences Education & Outreach, USA
Annamarie Schaecher, Cooperative Institute for Research in Environmental Sciences Education & Outreach, USA
Tamara Grybko, Reimagine Research Group, USA

ABSTRACT

We Are Water is an exhibition traveling to rural and Tribal libraries in the Southwestern United States to engage multi-generational audiences in exploring the science and cultural aspects of water in the region. This study focuses on how the project adapted research and evaluation methods used in informal settings to better suit the library context and audience and measure engagement. The Indigenous-inspired logic model guides the project, emphasizing collaboration and cultural relevance. Data collection happened through various means, including virtual interviews, in-person interactions, tablets, cards, and QR codes. The project employed local research assistants to aid data collection and instruments were adapted to incorporate diverse perspectives. Personal meaning maps became engagement tools, letting visitors depict local water concepts. Indigenous-inspired Talk Story interviews aided knowledge transfer and fostered community-driven interaction.

Findings highlight engagement of library audiences through events, interactive exhibits, programs, and community contributions. Visitors reported deeper understanding of water topics, stronger community bonds, and cultural appreciation. Library staff praised the project's educational and intergenerational value, as well as how it aligned with community goals. This study underscores the importance of tailoring methods to the local context, and shows how the project empowers underserved rural libraries with immersive, community-driven informal science education.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Understanding the Use of Models and Representations in Science Learning and Teaching
17-Mar-24, 3:00 PM-4:30 PM
Location: Governor's Square 16

The Iterative Design of a Model-Based Inquiry Planning Tool for Preservice Science Teachers
Todd Campbell*, University of Connecticut, USA
Ron Gray, Northern Arizona University, USA
Yue Bai*, University of Connecticut, USA
Stefani Chase*, Northern Arizona University, USA

ABSTRACT
Researchers have called for the development of tools (e.g., planning tools) and practices (e.g., moment-to-moment instructional moves) around which deliberate socio-professional practices can be collaboratively tested and refined to support implementation of the ambitious forms of science instruction. Currently, NGSS-designed curricula exist (e.g., OpenSciEd), however no unit planning tools are broadly available to support preservice science teachers (PSTs) engagement in the educative and collaborative design of their own curriculum. While access to previously designed curricular resources are important, we believe planning practices are also needed that seek to leverage professional and local knowledge of students and communities as part of curricular design. Given this, our design-based research is focused on the iterative design of a model-based inquiry planning tool for preservice teachers. In this presentation, we will share the ways in which we have drawn on data from methods classroom videos, planning artifacts, and interviews, as well as K-12 student surveys focused on opportunities to learn, to investigate and refine our planning tool. As one example, refinements made in response to PSTs' uncertainty and ambiguity experienced in relation to identifying a unit anchoring phenomenon, centering social justice and equity, and developing a driving question, will be shared.

Pre-Service Science Teachers' Perception of Mathematical Equations as Scientific Models Across Scientific Disciplines
FangFang Zhao*, Beijing Normal University, China
Jie Yang, Beijing Normal University, China

ABSTRACT
Mathematics in science plays a vital role in advancing scientific inquiry, and students need to be familiar with the role of mathematics in science as to understand how science works. Using mathematical models to connect pre-service science teachers (PSTs) from different scientific disciplines will be an effective way to develop their transdisciplinary perspectives. Using a case study method, this study investigated PSTs' perception of scientific models and what features of equations fit their definition for scientific models from physics, chemistry, biology and geology education track. Data of 267 PSTs' responses to three questions were

analyzed using epistemic criteria and blended sensemaking framework. Results show that PSTs across disciplines spontaneously referred to physical models as examples, except for physics PST. PSTs' perception of whether mathematical equations were scientific models reveals their positivism perspective of equations and the lack of connecting math to science. Suggestions were given on how to prepare future teachers with transdisciplinary perspective.

Modeling the Interplay Between Creativity and Knowledge through Pre-Service Science Teachers' Creative Instructional Design Practices

Alper Durukan*, Van Yuzuncu Yil University, Turkey
Jale Cakiroglu, Middle East Technical University, Turkey
Sevgi Aydin Gunbatar, Van Yuzuncu Yil University, Turkey

ABSTRACT

This study explores the interplay between Technological-Pedagogical-Content Knowledge (TPACK) and creativity among pre-service science teachers (PSTs). Through a design-oriented intervention, the study involved 14 3rd-year PSTs enrolled in the "Material Design in Science Teaching" course at a Turkish state university during the 2022-2023 Fall semester. The study followed a design-based methodology with a mixed-method approach. Quantitative data were collected before and after the intervention to gauge participants' self-ratings for TPACK and self-assessed/measured creativity. Qualitative instruments, including focus group interviews, videography method, observations, interactive-reflective journals, and researcher's field notes, were used for reflexive thematic and descriptive/content analyses. During the intervention, we introduced new educational technologies and encouraged their integration into the curriculum. Later, PSTs were tasked with designing digital instructional materials for specific objectives, assessed in creativity. Lastly, groups designed XR-assisted learning experiences for the given objectives and assessed for TPACK-laden technology integration quality. The findings revealed a compelling interplay between self-rated/enacted TPACK with measured/self-assessed creative traits. Notably, there were positive correlations between technology integration quality, creativity of the designs, and self-rated TPACK. The conclusions highlight the multifaceted interplay between creativity and TPACK, proposing the need to reconstruct the science teacher knowledge paradigm in research and practice.

Examining Changes in Representations in Prospective Elementary Teachers' Explanatory Models in a Content-Focused Course

Alexandria Call*, Northern Arizona University, USA
Martha Canipe*, Northern Arizona University, USA

ABSTRACT

Developing and using models is a key practice of science and engineering. An explanatory model uses representations to communicate an explanation of s scientific phenomenon. These types of models are a key practice of Ambitious Science Teaching. In this pilot study, we examined the explanatory models developed by prospective elementary teachers enrolled in an undergraduate phenomenon-based science content course. We explored what representational tools they used in their models and whether the tools used in initial

and final models differed. Findings showed that a variety of representational tools were used to communicate relationships, time sequence, and scale in the models. We also found that there were some shifts in which tools were used between initial and final models. Additionally, it seemed as though the phenomena themselves influenced which tools were used. This was somewhat surprising given that the explanations for all the phenomena included relationships between elements and a time sequence, but these were not represented in all of the final models.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Teacher Sensemaking in Professional Development Contexts
17-Mar-24, 3:00 PM-4:30 PM
Location: Directors Row H

Sensemaking of District Provided Curriculum: How Teachers Adapt Resources in their Own Context

Joe DeLuca*, University of Georgia, USA
Julie Luft, University of Georgia, USA
Ella Yonai, University of Georgia, USA

ABSTRACT
A multiple case study was conducted to understand how six science teachers from three school districts used district provided resources such as pacing guides to plan and implement science lessons. With the transition to three-dimensional science instruction, the resources teachers have access to and use to plan instruction have the potential to greatly influence what occurs in the classroom. An analysis of semi-structured interviews, lesson artifacts, and a weekly planner was made using a sensemaking framework to identify when teachers experienced ambiguity and uncertainty with the resources provided by their district. The fidelity of implementation was then analyzed by comparing lesson activities with curriculum goals. Initial findings from one of the six cases show that the ambiguity and uncertainty some teachers faced when engaging with district provided resources can lead to the selection and implementation of activities found using Open Education Resources that do not align with curriculum goals. These findings have implications for those working in school districts to develop curriculum resources for teachers, other curriculum developers, those interested in 3D science instruction, and related fields.

Professional Learning to Support Elementary Teachers' Systems Thinking

Jennifer Maeng, University of Virginia, USA
Amanda Gonczi*, Michigan Technological University, USA
Ruohan Liu, University of Virginia, USA
Robert Handler, Michigan Technological University, USA

ABSTRACT
Understanding what constitutes a system and being able to reason about variables that influence the outcomes of natural systems and functions of man-made systems (systems thinking; ST) is a critical 21st century skill. This study investigated how elementary teacher understandings of systems and ST changed following a professional learning (PL) experience and the components of the PL they found most supportive in improving understandings. Teacher understanding of systems and ST and ability to differentiate between cycles/processes and systems improved as did their confidence to integrate ST ($p < .001$). Teachers' drawings of a school system were more likely to include clear boundaries, inputs and outputs, and directional interactions following PL compared to prior to PL. Teachers attributed improvements to inclusion of modeled lessons, discussions, and lesson plan development during the PL.

"Taking Action to Make Change": Capturing Science Teachers' Conceptions of Content Critique

Matthew Wilsey*, Stanford University, USA
Monica Sircar*, Stanford University, USA

ABSTRACT
Although both national documents and educational scholars have called for greater attention to equity in science classrooms, it is not clear that all stakeholders share common understandings of equitable science instruction. This study explores how secondary science teachers – potentially those most responsible for equitable science teaching and learning in classrooms – conceptualize one aspect of equitable science teaching, Content Critique, and how those conceptions shift, if at all, through professional learning (PL). Using drawn mental models as a proxy for capturing teachers' conceptions, data was collected from ten science teachers during the third summer of a longitudinal PL on instructional practice and educational equity. The results suggest that teachers' conceptions were only partially aligned with existing frameworks for equitable science teaching. However, there were visible changes between the pre- and post-models. Though there were fewer codes in the final models, there was a clear shift from teachers detailing a collection of elements of Content Critique to a more holistic understanding of how Content Critique could be operationalized in a science classroom. Further, themes of empowering students for action and developing a strong classroom culture emerged. Since conceptions can influence practice, implications for PL are discussed.

Moments of Dissonance in a Professional Learning Community Toward Culturally and Linguistically Sustaining Science Teaching

Victor Leos*, University of Colorado Boulder, USA
Melissa Braaten, University of Colorado Boulder, USA
Loraine Glidewell, University of Colorado Boulder, USA

ABSTRACT
There is an ongoing push in the field of science education for more culturally and linguistically sustaining pedagogical shifts as well as for more ambitious forms of science

teaching. Learning communities, such as professional development opportunities, can be generative spaces for teachers as they experience moments of tension and dissonance while critically reflecting on these equitable teaching practices. The guiding question of this case study was, how do dilemmas of practice and areas of dissonance invite, engage, and potentially clash with institutional and cultural contexts needed to support and sustain pedagogical shifts and professional leadership and learning opportunities? We answered this question by outlining three areas of tension that teacher participants experienced throughout a professional learning community centered on equitable teaching practices in science education. The tensions traversed internal and external contradictions that teachers face when making sense of new teaching practices and pedagogical moves. These findings have implications for future designs around teacher learning as well as areas for scholars to explore regarding recommendations of pedagogy and practice within U.S. public schools.

Strand 10: Curriculum and Assessment
Related Paper Set
Partnering with Teachers to Customize Curriculum and Assessment for Meaningful Student Learning
17-Mar-24, 3:00 PM-4:30 PM
Location: Directors Row J

Partnering With Teachers to Localize a Climate Learning Experience for Students
Lindsey Mohan*, BSCS Science Learning, USA
Emily Harris, BSCS Science Learning, USA
Candice Guy-Gaytan, BSCS Science Learning, USA
Audrey Mohan, BSCS Science Learning, USA
Betty Stennett, BSCS Science Learning, USA

ABSTRACT

Achieving the ambitious goals for science education set forth by Framework and the NGSS requires science teaching and learning to connect with student interests, identities, and experiences as youth investigate phenomena in the world. We approached this challenge in the context of supporting youth to cultivate a sense of environmental science agency as they investigate locally relevant climate impacts and solutions. We partnered with 28 high school teachers across the U.S. to help them design and customize a climate change learning experience with locally meaningful phenomena. Teachers were provided with a 10-lesson base unit that engaged students in understanding the mechanisms behind climate change and solutions to rebalance the carbon system. We supported teachers to create a local storyline around the base unit that anchored students' learning in a local climate impact and culminated in a local climate change action. Teachers reported that their greatest success in the professional development program was learning to create a coherent storyline. Challenges persisted in structuring teacher learning for storyline design work and providing the right support and resources.

Supporting Teachers in the Selection of Meaningful Phenomena for Assessment Design.
Sara Cooper*, University of Colorado, USA
Abraham Lo, BSCS Science Learning, USA

ABSTRACT
This paper addresses the need for a shift in assessment practices within science education to promote diverse sensemaking. In line with the vision of the NRC (2012)'s A Framework for K-12 Science Education, this study aims to establish a more coherent system of teaching, learning, and assessment that aligns with equitable opportunities for all learners. The paper emphasizes the importance of not only aligning assessments with the three dimensions of the standards, but also taking into account learners' interests and identities to create meaningful, engaging, and relevant assessment opportunities.
The study focuses on the critical aspect of selecting meaningful phenomena to drive sensemaking. The intervention was a three-month, online professional learning course designed to enhance teachers' professional design capacity. The research examines 22 secondary science teachers who participated in the course in the fall of 2022. Applying Suárez and Bell's (2019) framework, the paper categorizes the selected phenomena of teachers' in-course assessment design. The majority of phenomena selected were "everyday" phenomena and the least represented class of phenomena was culturally significant. Most teachers selected phenomena falling within the natural/cultural framework, however five did not fit the selected phenomena classes framework.

Examining Teachers' Multimodal Customizations to Support Multilingual Students' Equitable Sensemaking.
Samuel Lee*, Boston College, USA
Katherine McNeill, Boston College, USA

ABSTRACT
With a growing multilingual population of students and a majority monolingual science teaching demographic, teachers need creative ways in order to customize curriculum that is linguistically inclusive and supports students' multiple ways of knowing. This qualitative case study investigates a research practice partnership in order to co-design curricular customizations that support emergent multilingual learners' (EMLs) equitable sensemaking. We use thematic analysis of customized instructional materials along with video footage of three 8th grade teachers' planning, classroom enactment, and post enactment reflections. With our conceptual framework of different multimodality roles, our emergent findings indicate teachers used a variety of roles across a lesson in order to support a more sensemaking intensive argument task. We argue that such a variety of customizations with different multimodality roles, some small and large, better positioned EMLs as epistemic agents within sensemaking intensive activities.

Examining What Phenomena Matter to Students in a Customizable Unit
Candice Guy-Gaytàn*, BSCS Science Learning, USA
Awais Syed, BSCS Science Learning, USA
Emily Harris, BSCS Science Learning, USA

Lindsey Mohan, BSCS Science Learning, USA

ABSTRACT
NGSS calls for using real world phenomena that matter to students to motivate sensemaking, which presents a challenge when designing curriculum for broad use. Meaningful phenomena may include phenomena with local or global impact that are culturally significant, contemporary scientific, societally relevant, or experienced daily; therefore, what is meaningful for students can differ across individuals and communities. In our project we collaborated with teachers to design a storyline unit that included anchoring, investigative, and related phenomena and that also allowed for customizing phenomena to address students' interests, identities, and communities. In this paper, we present a case study of four, fourth-grade students and explore their experiences with designed for and teacher customized phenomena. Analysis of focus group interview data revealed descriptors students used to identify what makes phenomena interesting and meaningful to them. Results suggest that interesting and meaningful phenomena are those that are observable in their daily lives and impactful on their communities. Further analysis will focus on how meaningfulness influences student sensemaking of those phenomena. This case-study paper will be of consequence to researchers and curriculum designers interested in pedagogical supports for customizing units in ways that support student sensemaking while also attending to students interests and identities.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set
Teacher Education: Teacher Knowledge, Beliefs, Persistence
17-Mar-24, 3:00 PM-4:30 PM
Location: Governor's Square 17

Understanding the Conceptualisations of Coherence in Science Instruction and Teacher Education – A Systematic Literature Review

Mathias Ropohl, University of Duisburg-Essen, Germany
Stefan Sorge*, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Ibrahim Delen, Usak University, Turkey
Robert Evans, University of Copenhagen, Denmark
Kalle Juuti, University of Helsinki, Finland
Jari Lavonen, University of Helsinki, Finland
Pernilla Nilsson, Halmstad University, Sweden
Dustin Schiering, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Matthias Stadler, University of Bergen, Norway
Jeffrey Nordine, University of Iowa, USA

ABSTRACT
Over the past decade, science education standards across the globe have undergone changes by shifting the focus towards greater coherence in science instruction. This call for coherence seeks to counter the fragmented nature of existing curricula. However, the term

"coherence" remains multifaceted in science education research. This issue also applies to coherence in science teacher education, complicating the preparation of science teachers to enact coherent science instruction. To tackle these issues, we present a systematic literature review aimed at disentangling the diverse perspectives on coherence in both science instruction and teacher education. Using 62 keywords, we collected more than 5,000 publications from which 38 addressed coherence in science instruction or science teacher education. Most publications offered vague characterizations or multiple interpretations of coherence; only ten publications provided an explicit definition. The definitions of coherence addressed multiple facets ranging from curriculum alignment to student understanding and teaching practices. The findings underscore the necessity of clarifying the concept of coherence in science education and teacher education. The lack of consensus hampers the development of effective curriculum materials and teacher education programs aligned with the evolving science standards.

Understanding Estonian Science Teachers' Beliefs About Teaching and Assessment of Scientific Competences

Triin Rosin*, University of Tartu, Estonia
Katrin Vaino, University of Tartu, Estonia
Regina Soobard, University of Tartu, Estonia
Miia Rannikmäe, University of Tartu, Estonia

ABSTRACT
The aim of this study is to understand science teachers' beliefs about teaching and assessment in the context of Estonian national science e-testing, and with respect to the competences highlighted by the test. Semi-structured interviews were conducted with 15 science teachers from selected schools taking part in testing in 2021. The interviews were analysed by means of qualitative content analysis. Teacher beliefs were categorised based on the theory of planned behaviour (Ajzen, 2005), and two other frameworks such as approaches to teaching developed by Trigwell, 2012 and purposes of assessment developed by Brown, 2008. The preliminary results of the first three interviews were presented in this paper. Further results will be presented and discussed in the NARST.

A Case Study of Biology Teachers' Persistence to Implement Reform Curriculum

Elizabeth de los Santos*, University of Nevada, Reno, USA
Kathleen Stynen*, Washoe County School District, USA
Faith Osgard*, Washoe County School District, USA
Suzanne Lewis*, University of Nevada, Reno, USA
Sylvia Scoggin*, Washoe County School District, USA

ABSTRACT
Alignment between curriculum, instruction, and assessment can support teachers to implement science education reforms. School districts are well-positioned to support alignment through their responsibilities for curriculum, teacher professional learning, and assessment at classroom and district levels. Using self-directed learning theory from adult learning theory, we investigated a case of two biology teachers' persistence to implement

reform curriculum given the implementation of a districtwide science assessment aligned with state standards. We examined what, why, and how teachers wanted to spend time and effort learning the curriculum within the context of their school and district organizational contexts. Data sources included semi-structured interviews, classroom observations, and longitudinal student assessment data. We identified teachers' motivations for pursuing professional learning, including intrinsic and external factors, and school and district practices and policies that supported teacher autonomy and accountability.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Critical Race Theories: Recovering Counterstories and Grappling with Slow Violence Across STEM and Teacher Education
17-Mar-24, 3:00 PM-4:30 PM
Location: Governor's Square 14

We Missed A Step: Recovering Black Participation in Science Education
Tiffany Butler*, George Mason University, USA

ABSTRACT
This study examines the experiences of Black Americans in science education in the United States during the Space Race. Utilizing a critical race theory approach within narrative inquiry, this study used counterstories, tools that the historically marginalized and minoritized have used to challenge masternarratives. Four participants were interviewed about their high school science experiences, and their interviews were analyzed using thematic coding. Three themes were found to be related to the Black American experience in science education during the Space Race: community, quality of instruction, and identity. The participants' rich counterstories illuminate how important oft-overlooked aspects of school can become cultural exclusions for students not of the dominant classes.

Whiteness, Slow Violence and the Enclosure of STEM Pathways
Jennifer Adams*, University of Calgary, Canada
Preeti Gupta, The American Museum of Natural History, USA
Rachel Chaffe, The American Museum of Natural History, USA
Mahmoud Abouelkheir, The American Museum of Natural History, USA
Jahneal Francis, Northeastern University, USA

ABSTRACT
With microaggressions being an oft-cited problem for racialized people in STEM, in this paper, we unpack this issue through the lenses of slow violence and whiteness. We demonstrate the ways that the embedded whiteness in STEM spaces produce the microaggressions that racialized students experience, creating a process of slow violence that either keeps them marginalized or pushed out of STEM pathways. We draw from a 10-year (now in year 7) longitudinal mixed methods study that follows the career pathways of students who completed an out-of-school mentored science research program in a large,

urban center. The study includes a sample of youth and new adults (N=384) predominantly of color and/or first generation. Findings from this study have the potential to impact our understanding of the ways in which the nature and persistence of microaggressions are connected to the embedded whiteness of STEM and contributes to the ongoing demographic inequities. Elucidating and uprooting this underlying culture that privileges whiteness is critical if we are to achieve equity and flourishing in STEM education and careers.

Educating Preservice Teachers While Black and White: Science as White Property in Teacher Education

Jonathan McCausland*, New Mexico Highlands University, USA
Jennifer Jackson*, Pennsylvania State University, USA

ABSTRACT

This proposal addresses how white supremacy shapes the experiences of science teacher educators. By drawing upon theories about whiteness, this study uses duoethnographic racialized storytelling to describe the experiences of two differently raced teacher educators. The stories reveal how science as white property (Mensah & Jackson, 2018) is produced by the different interactions White preservice teachers have when learning from a White teacher educator versus a Black teacher educator. We argue that this proposal demonstrates the need for White teacher educators to take on a more substantial role when preparing White preservice teachers and that science teacher education must look for ways to create teacher education contexts for teacher educators of Color that prevent or at least mitigate the potential harm done to them by White preservice teachers.

Race in Teacher Educator Preparation: The Black Doll White Doll Experiment Becomes Personal

Felicia Mensah*, Teachers College, Columbia University, USA

ABSTRACT

Researchers note that few doctoral programs prepare their graduate students for the work of teacher education. This study specifically engages students in experiencing and reflecting on race through watching a video clip for their development of racial literacy and racial consciousness as teacher educators. The participants engaged in the Black White Doll Activity as a simulation racial experiment in a course on race and teacher education. This research utilized qualitative phenomenological methodology. The participants were nine doctoral students across two departments and programs (Science Education & Curriculum and Teaching) at a large graduate school of education. Using methods of constructivist grounded theory, in vivo coding, and emotions coding of individual e-Journals and group artifacts, three themes are shared: (1) The participants discuss and feel the impact of race, racism, and whiteness on young children as they also recall their experiences with race and whiteness. (2) Even as they imagine themselves as participants in the doll tests, they feel sad, mad, and disgusted at how early children experience racism and whiteness. (3) They express notions of Black acceptance and colorism. As the clip brings out emotions, the video clip is a teaching tool to initiate challenging conversations about race in education.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Transforming Science Education: LGBTQIA+ Perspectives, Queer Theories, and Gender-Inclusive Approaches
17-Mar-24, 3:00 PM-4:30 PM
Location: Governor's Square 12

"You're a girl": Queer Students and Teachers, Violence, and Science Education after COVID-19

Matthew Weinstein*, University of Washington - Tacoma, USA
Alysa Schafer, Tacoma School District, USA

ABSTRACT
This paper examines the impact of COVID-19 on LGBTQIA+ youth and their larger communities. The paper explores the challenges faced by queer youth and teachers upon the reopening of in-person schooling through witnessings and narratives of explicit transphobia and hate speech. We specifically chronicle and analyze such moments in a secondary science class, and then contextualize these moments through discourse analysis of architecture, curriculum, speech, policy, and popular culture as they intersect in this science space. Our discourse analysis draws on Donna Haraway's concept of natureculture to look at the reiterated and mutually reinforcing presumptions and declarations that sexgender is exclusively and naturally binary to make sense of students' experiences of exclusion. We also examine the ways that science is "conjured" to naturalize these dualistic framings. We contrast these dualistic ideologies of sexgender with contemporary scientific models and research on sexgender ontogenesis, the latter modeling it as a complex choreography with multiple sexgender resulting possibilities, but note the absence of any such science in the school's curricula. Our paper concludes by providing a set of necessary transformations in science education to establish supportive and inclusive classrooms and school cultures.

The Science Classroom as a Gendered Space and the Consequences for Learning Science

Gry Thorsen*, University of Copenhagen, Denmark
Henriette Holmegaard, University of Copenhagen, Denmark
Lene Madsen, University of Copenhagen, Denmark

ABSTRACT
This paper is part of a larger 3-year ethnographic study that investigates the science learning environment at a three-year, non-compulsory upper secondary school and how it is gendered. The outset of the study is the fact that many science classrooms seem to be gendered in ways that favor masculinity (Danielsson, 2014). The study builds on feminist, poststructuralist theory and critical masculinity studies and combines this theoretical outset with ethnographic fieldwork. Through analysis of empirical findings obtained through in-depth participant observations and semi-structured interviews the authors show that female

students are positioned differently than male students by the teacher as well as their peers. This create unequal opportunities for the students to be recognized as legitimate participants in the science classroom and it questions some of the pedagogic practices. The Paper concludes, that if we want to include more girls and women in science, we need to be aware of how gender norms intersect with who and what is celebrated as talent in the science classroom and who and what is overlooked.

Affirming Queerness in Biology: Teaching Diversity Not Cisheteronormativity

Aramati Casper*, Colorado State University, USA
Beth Wittmann, Colorado State University, USA
Ollie Turner, Colorado state university, USA
Elliot Batta, Colorado State University, USA
Kelly Lane, University of Minnesota - Twin Cities, USA
Sarah Eddy, University of Minnesota - Twin Cities, USA

ABSTRACT

The number of individuals whose gender does not match the sex they were assigned at birth is growing, yet our understanding of how to support these students in educational settings lags behind. The little research that exists suggests that these students experience reduced persistence and belonging in undergraduate STEM disciplines. In this U.S.-wide qualitative study, we explored the experiences of undergraduates with queer genders in life science majors using master narrative theory to characterize the narratives students encountered in their courses, focusing on positive experiences that bolstered their belonging and their ability to resist harmful narratives about sex and gender. We recruited 48 students from across the U.S. We used reflexive thematic analysis and identified four queer-inclusive narratives about sex and gender that students experienced in their courses and two alternative narratives about the roles of identity in science that also supported student belonging. These finding demonstrate ways that life-science content can support students with queer genders and provides a potential path to create biology classrooms where students with queer genders are supported rather than excluded.

(TRANS)forming LGBTQ- and Gender-Inclusive Science Education

Ren Rende*, University of Nebraska at Omaha, USA
Carla Johnson*, North Carolina State University, USA

ABSTRACT

The realization of gender-inclusive science education remains a pervasive challenge today, despite considerable progress over the past decade recognizing the importance of enacting an inclusive approach to the teaching of science for women and girls. However, other gender-marginalized groups including transgender, non-binary, and gender non-conforming youth continue to be underrepresented in gender-inclusive education reform movement.

In response to these pervasive challenges, and to grow the knowledge base regarding gender and LGBTQ+-inclusive science education, this study explored the pedagogical practices of 10 transgender science teachers with the purpose of learning from their

experiences creating inclusive curriculum. Emergent in the data (in-depth interviews, instructional materials samples, and reflective teaching statements) was an overarching TRANS (Trans and Research-informed Approaches for Nonbinary and gender-inclusive Science education) Framework for gender-inclusive science education pedagogy.
The findings of this study contribute to our growing understanding of gender-inclusive science learning environments. Importantly, this study amplified the experiential knowledge of teachers whose voices are critically absent from research surrounding gender and LGBTQ+-inclusive science education practice. Moreover, the framework derived from teachers' experiences can be used to guide educators in making their science classrooms safer and more inclusive for trans, nonbinary, and gender-creative youth.

Strand 12: Technology for Teaching, Learning, and Research

Related Paper Set

Challenges of Using AI for Evaluation of Knowledge-in-use Assessments

17-Mar-24, 3:00 PM-4:30 PM

Location: Governor's Square 15

Rubric Development for AI Scoring of NGSS Learning Progression-Based Scientific Models To Support Individual Opportunity To Learn

Leonora Kaldaras*, University of Colorado Boulder, USA
Tingting Li, Michigan State University, USA
Kevin Haudek, Michigan State University, USA
Joseph Krajcik, Michigan State University, USA

ABSTRACT

In this session, we focus on examining applications of artificial intelligence (AI) to augment and advance formative assessment practices. We present evidence from studies to support the use of AI as part of the development and evaluation stages of formative assessment. Four empirical papers in this related paper set explore the challenges of applying AI to formative assessment in STEM and discuss how the science education research community can help shape the future of AI-based formative assessment practices. Aligned with the Framework for K-12 Science Education, the move to knowledge-in-use assessments allows students to demonstrate proficiency in multi-dimensional learning. The papers in this session examine a number of challenges with employing AI for such science assessment; both in the development of such assessments and evaluation of student responses to these assessments. All four papers focus on using AI to support the use of knowledge-in-use assessment in classrooms. However, each paper focuses on a different challenge to using AI for this purpose. Further, several different applications of different AI techniques are considered across the set, thus providing a broader context for the use of AI in education and presenting contrasting challenges for different applications.

Utilizing Deep Learning AI to Evaluate Scientific Models: Overcoming the Challenges

Tingting Li*, Michigan State University, USA
Leonora Kaldaras, University of Colorado Boulder, USA

Kevin Haudek, Michigan State University, USA
Joseph Krajcik, Michigan State University, USA

ABSTRACT
Modeling is crucial for enhancing students' knowledge-in-use, particularly through multimodal assessments in the realm of three-dimensional science learning. Despite their significance, the intricate and diverse nature of these models complicates their evaluation. Additionally, assessing models, intended to gauge students' knowledge-in-use, presents challenges due to its multifaceted cognitive essence. While Artificial Intelligence (AI) promises solutions, there's a limited body of research on effective deployment of AI for assessing students' models. This gap results from the distinct attributes of educational data, often smaller compared to other fields, and the complexity of the knowledge-in-use framework, which demands an integrated understanding of phenomena across various dimensions. Recognizing this, our study explores how to use various AI strategies to improve machine performance by automatically assessing students' scientific models.

Improving Machine Scoring Performance with Unbalanced Training Dataset
Xinyu He*, University of Georgia, USA
Xiaoming Zhai, University of Georgia, USA
Peng He, Michigan State University, USA
Ehsan Latif, University of Georgia, USA

ABSTRACT
This study thus investigated how to improve scoring model accuracy with an unbalanced dataset by adjusting scoring rubrics. We collected 1197 students' responses about chemical reactions based on provided evidence. Trained content experts used a 10-aspect analytical scoring rubric to assign binary scores for students' responses. Observing limited responses for certain aspects and limited scoring accuracy, we combined some aspects, like E2-E5, into a new category and compared whether the adjustment of scoring rubrics can improve scoring model performance. We conducted three adjustments. In each adjustment, students describe the pattern in at least one/two/three types of data as evidence. We employed TensorFlow to train a multilabel text classification scoring model. The results show that the accuracy has improved after merging aspects together. This study investigated a strategy to improve model performance with an unbalanced dataset by combining related scoring aspects, which can engage discussions on how to design and revise rubrics that are suitable for automatic scoring.

Using Generative AI to Automatically Identify Students' Three-Dimensional Understanding in an NGSS-Aligned Learning Progression
Peng He *, Michigan State University CREATE for STEM Institute, USA
Namsoo Shin, Michigan State University CREATE for STEM Institute, USA
Joseph Krajcik, Michigan State University CREATE for STEM Institute, USA

ABSTRACT
Providing students and teachers with timely information on assessment performance is essential for supporting students to move forward to the next levels in a learning progression. Artificial Intelligence (AI) technologies, such as Machine Learning (ML), have been widely used to develop algorithmic models to interpret automatically students constructed responses on assessment tasks. There is limited knowledge about how AI can generate valuable information to support student learning along LP over time. Addressing the challenges above, we use generative AI (e.g., GPT) to automatically identify students' three-dimensional understanding in our designed NGSS-aligned learning progression.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set
K-12 Teaching and Learning
17-Mar-24, 3:00 PM-4:30 PM
Location: Plaza Court 1

Student-Led Participatory Science Curriculum Encourages Science Identity Development in High School Students

Charlie Blake*, Southern Illinois University Edwardsville, USA
Andreia Dexheimer*, Southern Illinois University Edwardsville, USA
Carol Colaninno, Emory University, USA
Candice Johnson, Southern Illinois University Edwardsville, USA
Adriana Martinez, Southern Illinois University Edwardsville, USA
Benjamin Greenfield, University of Southern Maine, USA
Sharon Locke, Southern Illinois University Edwardsville, USA
Georgia Bracey, Southern Illinois University Edwardsville, USA

ABSTRACT
We developed a curriculum and asked how our community-focused environmental science program impacted students' science identity development. We also explored how well Carlone and Johnson's (2007) three part model of identity based on performance, competence, and recognition was able to capture our students' experiences. We implemented our curriculum in an out-of-school context that emphasized student choice where high schoolers designed and performed participatory science research on local environmental issues. Through qualitative analysis of student interviews we propose several modifications to Carlone and Johnson's previous model including the impact of students' preexisting definition of a scientist based on their ideas about who a scientist is and what they do. Our findings show that students' preconceived definition of a "scientist" can interfere with their ability to recognize potential role models and to see themselves as scientists. Our findings illustrate the importance of countering stereotypes about scientists and emphasizing that performing scientific tasks is a part of becoming a scientist, with the goal of broadening students' definition of a scientist into one that could include themselves. This work will intrigue researchers and practitioners interested in science identity development, which also impacts who will become a part of the future STEM workforce.

Developing a Contextual Questionnaire to Investigate Middle Students' View on the Nature of Science

Jie Yang*, Beijing Normal University, China
Sisi Han, Capital Normal University, China
Fangfang Zhao, Beijing Normal University, China

ABSTRACT

It's challenging to measure middle school students' understanding of the nature of science (NOS). This study developed an empirically based questionnaire to monitor middle school students' views on NOS. The Nature of Science Questionnaire (NOSQ) questionnaire measured views on Aims and Values, Methods and Methodological Rules, Scientific Practices, and Scientific Knowledge. NOSQ was constructed through a systematic method: determined target NOS and clarified the necessary characteristics, contextual items, and draft items. The draft questionnaire was revised according to the result of the ex-ante analysis and pilot test. 20 out of 22 items were selected for the current version. It was further validated by a sample of 4424 students from four regions. Explore factor analysis was used in the initial stage to check the relationship between items and uncovered the underlying structure of a relatively large set of variables, then CFA was used to establish validity. The result showed that all of the sub-datasets from different regions could be explained by the 4-factor structure. The overall reliability as measured by Cronbach's alpha was 0.9, and the discrimination as measured by Spearman correlation is greater than 0.3. The instrument yields valid and reliable data useful for inferential statistics.

How do Science Teachers Transform their Understanding of Scientific Methods to their Teaching?

Busra Aksoz*, Bogazici University, Turkey
Ebru Kaya, Bogazici University, Turkey

ABSTRACT

This study is a part of a project which is based on Erduran and Dagher's (2014) Family Resemblance Approach (FRA) to Nature of Science (NOS), which has later been termed as "RFN" (Reconceptualized FRA-to-NOS) by Kaya and Erduran (2016). The RFN framework encompasses cognitive, epistemic, and social-institutional aspects of science. It offers pedagogical strategies and practical applications for science education settings. In the project, an online collaborative/reflective professional development (PD) program, including all RFN categories for in-service teachers, was developed. The current study aims to focus solely on science teachers' transformation of their understanding of scientific methods category of RFN in their classrooms. Four science teachers, having diverse teaching experiences participated in this study. Interviews, teacher journals, lesson plans, and observation protocols were used as the data sources. Each interview was transcribed, and related codes and themes were determined for both interviews and journals. A lesson plan assessment rubric and observation protocols were utilized. The findings indicated that after the workshops on scientific methods, science teachers started to think about diverse scientific methods and developed lesson plans incorporating diverse scientific methods. Classroom observations indicated that science teachers were moderately successful but needed to practice more for effective teaching.

Experiences that Teachers Attribute to the Development of their Epistemic Beliefs about Science Knowledge

Ellen Watson*, Brandon University, Canada
Sarah Ragoub*, University of Manitoba, Canada

ABSTRACT

Science teachers are often unaware of their epistemic beliefs or—even more troubling—espouse epistemic beliefs about science knowledge that do not align with those agreed upon by the academic community (i.e., the Nature of Science). As student beliefs are highly influenced by their teachers' beliefs, it is important that we, as science educators, develop science teachers with appropriate epistemic beliefs. To gain insight into how we might develop teachers' epistemic beliefs about science, these researchers explored what experiences science teachers perceive as informing the development of their epistemic beliefs about science. 21 science teachers and preservice science teachers across a Western Canadian province participated in semi-structured interviews aimed at discussing their epistemic beliefs and those experiences they saw as informing the development of these beliefs. A literature-defined framework was used to code through thematic analysis. Results showed that teachers generally held appropriate beliefs in some areas (i.e., the certainty of science) but shared common misconceptions in others (i.e., the source of science knowledge). This presentation describes experiences commonly shared by those teachers holding appropriate beliefs and those sharing misconceptions. Suggestions for consideration in future science teacher education based on study findings are discussed.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set
Place-Base Education
17-Mar-24, 3:00 PM-4:30 PM
Location: Governor's Square 11

Environmental Education: Solutions-Based Pedagogy to Avoid SuperDoom

Brandl Rayelynn*, Montana Technological University, USA
Chris Pavlovich*, Montana Technological University, USA

ABSTRACT

This session focuses on the strategies and efficacy of a place-based, K-12 environmental education program which strives to: (a) increase students' understanding of the nature of ecological impacts within their watershed as related to historic mining damage; and (b) increase students' sense of stewardship of newly restored landscapes. Typically a topic of doom and gloom, the program empowers students with data science and a solutions-based narrative. Pedagogical lessons learned and their implications for climate change education will be discussed.
Data representing 2,395 student pre_surveys and 2,409 student post_surveys were evaluated for student knowledge gains. Data representing 1,479 pre_surveys and 1,460 post_surveys

were evaluated for students' attitudes toward science and disposition toward caring for the environment. The results of this study support that the program's goals are being achieved. Students achieved statistically significant gains on knowledge surveys with a 33.4% overall gain pre_ to posttest ($p < 0.0001$). Students moved toward greater positive responses in both attitudes toward science and disposition toward caring for the environment with Cohen's d effect sizes of "medium effect" for caring toward the environment (d= 0.52) and "small effect" of positive disposition toward science (d = 0.24).

Place-Based Education in Diverse Urban Communities: The Case of Israel
Miri Yemini*, Technion, Israel

ABSTRACT
Place-based education is a pedagogical approach that emphasizes the connection between a learning process and a physical place. This mixed-methods study aims to explore how urban communities deliver Place-based education in Israel. We compared communities with high and low socio-economic status, as well as Arab, Jewish, and Bedouin schools, to analyze the availability of appropriate learning spaces in proximity to schools, combining these results with interviews and focus groups of teachers and students aimed to explore the actual use of Place-based education. Despite the found disparities in the availability of facilities across the country, schools' vision, coupled with teachers' autonomy and guidance, were found most critical to successful Place-based education implementation, while other variables such as ethnic differences, socioeconomic differences and local differences had little effect, if any, on it.

Promoting Scientific Literacy and Nature of Science in International Communities through Place-Based Socioscientific Issues Context
Daniel De Jesús*, Texas A&M University, USA
Benjamin Herman*, Texas A&M University, USA
Kira Delmore, Texas A&M University, USA

ABSTRACT
We aim to enhance scientific literacy through highly contextualized place-based interventions that connect informal place-based and formal science classroom instruction, focusing on local environmental socioscientific issues (SSI) and Nature of Science (NOS). Addressing scientific literacy achievement gaps, we employed a mixed-methods approach to investigate students' NOS and SSI perspectives. Collaboratively undertaken with international partners, a pilot intervention targeting bird migration SSI was designed, implemented, and assessed in Costa Rica. A second intervention will be performed in Chile (October/2023) with modifications from our pilot's results. While little change was demonstrated in participants' pre- and post-quantitative responses, our qualitative findings suggest students exposed to this curriculum developed more comprehensive understanding of how scientists investigate SSI and the sociocultural factors related to migratory birds. Our presentation will emphasize the need to bridge formal-informal science education and explore place-based instruction's potential to foster scientific literacy. We will delve into curriculum design nuances, important contextual factors in assessing NOS and SSI learning outcomes, and will highlight challenges and lessons we learned when working with

international collaborators. Our presentation will stimulate dialogue on how integrating place-based SSI instruction across informal-formal contexts prepare students for NOS comprehension and SSI engagement, captivating SSI and NOS researchers.

Impact of Interdisciplinary Integrated STEAM Garden-Based Curriculum on Students' Knowledge, Self-Efficacy, and Attitudes

Katherine Vela*, Utah State University, USA
Douglas Weber, Utah State University, USA
Rita Hagevik, University of North Carolina- Pembroke, USA
Michelle Parslow*, Utah State University, USA
Kathy Cabe Trundle, Utah State University, USA
Laura Wheeler, Brigham Young University, USA

ABSTRACT
Many people have negative misconceptions as to what a bee is, this can create negative feelings towards important pollinators (Holt-Taylor, 2017, Johnson et al., 2014, Schönfelder & Bogner, 2018). Mata et al., (2019) found as people became educated about bees, they were more likely to consider pollinators when planning their garden. The purpose of this study was to determine the impact of engaging students in interdisciplinary integrated STEAM curriculum on their knowledge of bees, self-efficacy toward environmental action and pollinator conservation, and their attitudes toward nature and bees. Students took four surveys to assess their knowledge, self-efficacy, and attitudes. Pairwise correlation analyses, t-tests, and effect sizes were calculated. Significantly positive relationships were found between students' self-efficacy toward environmental action and pollinator conservation and their attitudes toward nature. Results also indicated that knowledge of bees and self-efficacy toward environmental action significantly improved. These results indicate if we continue to engage students in interdisciplinary integrated STEAM garden-based curriculum, we can improve students' knowledge of bees and their confidence in protecting our environment. If we can continue to increase knowledge about pollinators and confidence in protecting our environment, hopefully we can improve pollinator conservation, and ultimately protect our food sources.

Strand 15: Policy, Reform, and Program Evaluation
SC-Organized Paper Set
Examining Teacher and Student Outcomes in STEM Learning Contexts
17-Mar-24, 3:00 PM-4:30 PM
Location: Directors Row I

Examining Advanced STEM Course Enrollment and Performance Trends in New Jersey Across District Factor Groups

Brian Baldwin*, Kean University, USA
Brandon Barbieri, Kean University, USA

ABSTRACT
This study examines the trends in enrollment and performance in Advanced Placement (AP) and International Baccalaureate (IB) STEM courses across different socioeconomic backgrounds in New Jersey. The manuscript utilizes data from the last five years of annual school performance reports released by the New Jersey Department of Education (NJDOE) and compares AP/IB enrollment and passing rates across all District Factor Groups (DFGs) in the state. The analysis reveals significant disparities in both access and achievement in AP/IB STEM courses across different socioeconomic backgrounds. The study highlights the importance of examining factors such as parental involvement, teacher quality, social justice, and childhood wealth inequality in addressing disparities in access and achievement in these courses. Policy recommendations are provided for improving access and achievement in AP and IB STEM courses and emphasize the need for a comprehensive and systemic approach to education reform.

Does Attending a Selective STEM High School Influence College Outcomes?
Jamie Elsner*, University of North Carolina at Chapel Hill, USA
William Zahran, University of North Carolina at Chapel Hill, USA
Isai Garcia-Baza, University of North Carolina at Chapel Hill, USA
Daniel Klasik, University of North Carolina at Chapel Hill, USA
Krissi Hewitt, North Carolina School of Science and Mathematics, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA

ABSTRACT
Specialized STEM high schools may promote participation in STEM by providing students with more exposure to advanced STEM coursework and research opportunities, which are typically not offered at traditional high schools. While some studies have linked STEM high schools with higher STEM graduation rates, little is known about college outcomes for underrepresented student populations who attended STEM high schools, including African American/Black, Hispanic/Latino, and female students. This study explores college outcomes (i.e., STEM degree completion, degree completion, time to degree completion, and STEM major declaration) for students who attended a selective STEM high school, either a residential or online program, in comparison to students who did not attend. We analyze the data using fixed effects regression models by race/ethnicity and gender. Furthermore, we consider students' interest in STEM by isolating a comparison group that declared STEM at any point during college. Overall, both the residential and online program were associated with better college outcomes. However, differences by race/ethnicity and gender for each program type and the impact of STEM interest are discussed in the full paper and presentation.

A Comparison of Retained vs. Non-Retained Novice Science Teachers in Four U.S. States From 2007-2018
Douglas Larkin*, Montclair State University, USA
Khadjia Ahmed, Montclair State University, USA
Suzanne Patzelt, Touro University, USA
Mayra Muñoz, Montclair State University, USA

ABSTRACT
The issue of science teacher retention, with specific emphasis on the problem of retaining novice science teachers has a unique presentation in the United States, where conditions of employment vary widely across the over 18,000 local education agencies, and teachers enter the classroom through an assorted array of pathways that may or may not include teacher preparation programs. The question investigated in this study is: Across different U.S. states, are there categorical differences between teachers who are identified as being retained (i.e. stayed with an employer at least 4 out of first 5 years) and those who were not? Using state-level staffing data sets in four U.S. states, this study presents a descriptive analysis of the differences between teachers who were retained and those who were not, both in terms of characteristics and contexts. Findings include large differences between states, but very few within states, including starting salary. Wisconsin had a far higher rate of teacher retention than other states in the study. There was a higher rate of retention in districts that had a science department size of between 25-50 people as compared with smaller or larger departments.

Colorado Science Education Research

Supporting Three-Dimensional Curriculum, Instruction, and Assessment Through a Ten-Year Research-Practice Partnership

Erin Furtak*, University of Colorado, USA
Samantha Duwe, Aurora Public Schools, USA

ABSTRACT
There is an emerging consensus in the field of science education toward three-dimensional reforms that combine students' opportunities to learn disciplinary core ideas by engaging in science practices and applying crosscutting concepts as they seek to understand compelling and puzzling phenomena. These reforms also emphasize the importance of centering the interests, linguistic resources, and lived experiences of learners historically held at the margins in science classrooms. In order to realize three-dimensional reforms in educational systems, we must build supports at the intersection of curriculum, instruction, and assessment. In this paper, we look retrospectively at a ten-year partnership between an R1 university and an ethnically, linguistically, and socioeconomically diverse Colorado school district. We analyze multiple studies conducted within the project toward larger efforts of science education reform for middle and high school learners. We use the lens of a classroom activity system and the concept of infrastructuring in research-practice partnerships to highlight how multiple projects within the partnership, each supported by different funding streams, have focused on three-dimensional curriculum, assessment, and instruction. We describe infrastructures built and what was learned in each study. Finally, we reflect on how this partnership informs larger efforts toward three-dimensional reforms in US education.

Colorado Science Education Research
Symposium
BSCS Then and Now: Advancing High Quality Science Education for All Learners
17-Mar-24, 4:45 PM-6:15 PM
Location: Governor's Square 10

BSCS Then and Now: Advancing High Quality Science Education for All Learners
Chris Wilson*, BSCS Science Learning, USA
Cari Herrmann Abell*, BSCS Science Learning, USA
Jody Bintz, BSCS Science Learning, USA
Abraham Lo, BSCS Science Learning, USA
Lindsey Mohan, BSCS Science Learning, USA
Jean Flanagan, BSCS Science Learning, USA
Candice Guy-Gaytán, BSCS Science Learning, USA
Diego Rojas, BSCS Science Learning, USA
Jeffrey Snowden, BSCS Science Learning, USA
Betty Stennett, BSCS Science Learning, USA
Sherry Hsi, BSCS Science Learning, USA

ABSTRACT
BSCS was founded in response to the urgent need to better prepare U.S. science teachers following the Soviet launch of Sputnik. Then, BSCS conducted research and development with scientists and teachers in close partnership to design for more coherence across biology topics and to support meaningful inquiry in a year-long high school curriculum. Thirty years later, the 5Es instructional model emerged from continued research-practice partnerships, guiding the further development of robust instructional materials across multiple projects, districts and institutions. Today, BSCS's research portfolio spans projects and initiatives to advance high quality science learning, teaching, and leadership development. Contemporary research includes studies of science teachers as they adapt and localize curricula to their diverse audiences; scenario-based assessments that can measure students' ability to engage in NGSS 3D learning; as well as research on instructional practices from engagement in online and video-based professional learning programs. BSCS's research also includes design research for out-of-school and STEM learners, community college students, and elementary-aged learners. This structured poster symposium will share a sampling of BSCS's current research and evaluation findings, and engage the NARST community in discussion and reflection on how we can collectively advance high quality science education for all.

Engineering Education (ENE-RIG)
Sponsored Session
Applying an Engineering Education Lens to Today's Socio-Scientific/Socio-Technical Realities: Public Health, Socioeconomic Inequality, Climate Change, Artificial Intelligence and Beyond
17-Mar-24, 4:45 PM-6:15 PM
Location: Governor's Square 16

Applying an Engineering Education Lens to Today's Socio-Scientific/Socio-Technical Realities: Public Health, Socioeconomic Inequality, Climate Change, Artificial Intelligence and Beyond

ORGANIZERS
Monica Cardella, Florida International University, USA
Pamela Lottero-Perdue, Towson University, USA

PANELISTS
John Settlage, University of Connecticut, USA
Christopher Wright, Drexel University, USA
Greses Pérez, Tufts University, USA
Senay Purzer, Purdue University, USA

ABSTRACT
In this session, panelists will share their ideas about how an engineering education lens may inform approaches to teaching, learning, and societal engagement around socio-scientific/socio-technical topics. This lens may include the utilization of engineering habits of mind, the application of design thinking, and/or the pedagogical approaches employed within engineering education. Collectively, the panelists and discussant have shared identities science and engineering educators with varied insights and experiences conducting research and working with diverse elementary through high school students and teachers. They have a deep interest in education that has the potential to create a more equitable world, a more scientifically and technically literate society, and one that sustains the health of the planet and its inhabitants. Panelists will respond to several key questions from the discussant followed by questions from the audience. Questions from the discussant will explore what engineering education has to offer as society tackles challenges like global pandemics, injustice and inequity, climate change, and artificial intelligence; how panelists' perspectives on these issues have been shaped by their work as educators and researchers; and how the engineering and science education of tomorrow—to better address these challenges—may look different than it looks now. The panelists for this session are Drs. Greses Pérez, Senay Purzer, John Settlage, and Christopher Wright.

ESERA
Sponsored Session
Re-imagining Science Education in Post-Pandemic Worlds & Uncertain Futures
17-Mar-24, 4:45 PM-6:15 PM
Location: Governor's Square 17

Re-imagining Science Education in Post-Pandemic Worlds & Uncertain Futures

ORGANIZERS
Giulia Tasquier, University of Bologna, Italy
Lucy Avraamidou, University of Groningen, Netherlands

PANELISTS
Mauricio Pietrocola, University of Sao Paulo, Brazil
Olivia Levrini, University of Bologna, Italy
Digna Couso, Universitat Autònoma de Barcelona, Spain

ABSTRACT
This ESERA-invited symposium aims to highlight highlights international perspectives, taking varied positions to examine to what extent and how science education research can interpret these changing times where many challenges (e.g., COVID-19 pandemic, climate and sustainability crises, human-technology hybridization) are dynamizing and facing the way scientific knowledge is offering lenses to interpret the world. One could argue that there has not been a time in recent history spotlighting the crucial role of science education in preparing a global society to understand the nature of scientific knowledge and enterprise and with abilities to engage in critical thinking about dynamic scientific information.
The goals and pedagogies of science education are suddenly different. How the public and media understand and talk about socio-scientific issues, sustainability, and scientific advances is quite telling for scientific literacy. To these effects, in what ways are the current challenges a wake-up call for what and how we teach and talk science? The speakers will discuss the driving forces for re-visioning, re-imagining, re-defining, and re-structuring science education. The discussion will center on questions such as: How successful are education systems in preparing citizens for real-time, real-life socioscientific issues that not only disrupt but change our social realities? What lessons were learned concerning policy, curriculum, sociocultural and sociopolitical pedagogies, nature of science, and connections across educational, technological, and societal contexts? What role do we, as a community of educators and researchers, have in the post-pandemic context for ensuring scientific literacy moving forward?

Strand 1: Science Learning: Development of student understanding
Symposium
Learning Progression Analytics: Analyzing student learning for the individualized development of competence
17-Mar-24, 4:45 PM-6:15 PM
Location: Plaza Court 2

Learning Progression Analytics: Analyzing student learning for the individualized development of competence

Marcus Kubsch*, Freie Universität, Germany
Berrit Czinczel*, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Jannik Lossjew*, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Tobias Wyrwich*, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Ute Harms, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Daniela Fiedler, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Nikol Rummel, Ruhr-Universität Bochum, Germany
Hendrik Drachsler, DIPF, Germany
Ulrike Cress, IWM, Germany
Knut Neumann, IPN – Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
Digital technologies are considered a means to support the individualization of teaching and learning. Individualization of teaching and learning requires tracking students' learning trajectories and taking respective instructional measures. Doing so is a challenge for teacher that digital technologies can help mitigate. As students are working with digital technologies, they produce data. In principle, analysis of this data using machine learning allows for the assessment of students' performance. To what extent this actually works as students work with digital technologies in regular instruction remains unclear.
The symposium will present findings from a project in which students' interactions with digital workbooks were analyzed using machine learning to investigate the extent to which i) the data produced through students' interactions with the digital workbook can help assess students' learning and ii) trajectories of students learning across multiple instructional activities can be identified. The symposium will give a introduction into the idea of the project, a presentation of three studies drawing on the combination of digital technologies and machine learning to understand learning trajectories against the backdrop of the learning progression underlying the units, and conclude with a discussion of the findings and their implications for the future of science education (research).

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
Socioscientific Issues
17-Mar-24, 4:45 PM-6:15 PM
Location: Plaza Court 4

Students' Socio-scientific Systems Thinking: The Role of Systems Mapping, Causal Reasoning, and Content Knowledge
Nannan Fan*, University of North Carolina at Chapel Hill, USA
Eric Kirk, University of North Carolina at Chapel Hill, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA
Heewoo Lee, University of North Carolina at Chapel Hill, USA
Linyu Yu, University of North Carolina at Chapel Hill, USA

ABSTRACT
The COVID-19 pandemic and plastic pollution underscore the importance of comprehending complex socio-scientific issues (SSI) as systems. Yet, students in formal science education rarely explore SSI through systems thinking due to intricate social-scientific components. The study aims to understand how students' systems mapping, causal reasoning, and science content knowledge impact their socio-scientific systems thinking performance, particularly in the context of the COVID-19 pandemic. This study collected students' science content knowledge on viruses, systems thinking score on COVID-19, and ability of drawing systems maps of COVID-19 in a course they took. The results showed that there were significant positive correlations between students' systems thinking score and science content knowledge and their ability to create complex systems maps and rate of plausible causal relationships. Notably, students' ability to create complex systems maps and their rate of plausible causal relationships were found to significantly predict their socio-scientific systems thinking scores. Science content knowledge initially played a role in predicting systems thinking but lost its significance when considering the impact of rate of plausible causal relationships.

The Role of Knowledge and Perspective-taking in Students' Performance of Socio-scientific Argumentation
Shih-Yeh Chen*, Department of Science Education and Application, National Taichung University of Education, Taiwan
Shiang-Yao Liu, Graduate Institute of Science Education, National Taiwan Normal University, Taiwan

ABSTRACT
Socio-scientific issues (SSIs) have become a topic and medium to present the influence of scientific enterprises on society and the environment. Owing to the plurality of the SSIs, adopting the argumentation process in science instruction allow learners to express their ideas from other points of view. Understanding factors influencing the performances of argumentation would be beneficial for enacting the lesson plan by considering students'

prior knowledge and teaching material. This study aims to explore the factors influencing the argumentation quality of students before/after the argumentation activity and the changes in the factors. Ninety-three ninth-grade students participated in this activity with pre-/post-test on scientific knowledge and argumentation performance. Results demonstrate the significant improvements in the knowledge test of solar energy and the number of environmental, social, scientific & technological, and economic arguments. The stepwise regression model shows the knowledge of solar energy and all argument types in the pre-test could predict argumentation quality. In the post-test, the scientific & technological argument type and knowledge of solar energy are the first and second variables entering the model, respectively. This research will further discuss how this teaching impacts the improvement of knowledge and argumentation.

Middle School Students' Informal Reasoning Quality, Attitudes Toward Socioscientific Issues and Motivation to Learn Science

Büsra Manay, Science Teacher, Turkey
Özgül Yılmaz Tüzün*, Middle East Technical University, Turkey

ABSTRACT
In this study the relationship between students' informal reasoning quality regarding socio-scientific issues (SSI), attitudes toward SSI and motivation to learn science was investigated. Data were obtained by using Informal Reasoning on SSI questionnaire, Pupils' Attitudes Towards Socio-scientific Issues (PASSI) and Students' Motivation toward Science Learning (SMTSL). The participants were 523 middle school students in 7th and 8th grades. Correlational research approach was used. Pearson correlation analysis showed that there was a correlation between informal reasoning quality and informal reasoning modes of the students. The results of multiple regression analysis showed that self-efficacy and relevance institution significantly contributed to the prediction of informal reasoning quality of middle school students. The integration of argumentation based socioscientific issues into science classes might be helpful for increasing their informal reasoning quality.

Exploring and Expanding the Frontiers of Socioscientific Issues

Dana Zeidler*, University of South Florida, USA
Troy Sadler*, University of North Carolina at Chapel Hill, USA

This paper provides a synthesis of research in the area of socioscientific issues (SSI) culled from the Handbook of Research on Science Education (3rd Edition) (Lederman, Zeidler, & Lederman 2022). It focuses on the extant literature and identifies specific trends and themes in the research focusing mainly on current research from 2013 to the present. We sought both empirical and conceptual studies, and the criteria for selection had to do with our collective understanding of rigorous scholarship that we found to be empirically and/or conceptually sound, as well as the degree to which the scholarship fit with four broad themes: 1) Socioscientific Issues as Engagement of Curriculum Practice and Teachers' Pedagogical Beliefs; 2) Socioscientific Issues and the Cultivation of Epistemic and Sense-making Practices; 3) Socioscientific Issues Outside of Conventional Classrooms: Informal, Place-based, Environmental and Other Sociocultural Contexts; and 4) Socioscientific Issues as Character Development, Citizenship and Socioscientific Perspective Taking. The SSI

framework is, at its core, a multidisciplinary approach to science teaching and learning aimed at advancing scientific literacy for all students. Implications for research and practice are discussed.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set
Early Childhood Science Practices
17-Mar-24, 4:45 PM-6:15 PM
Location: Plaza Court 3

Playing in Science: Exploring Play-Based Science Learning Across Different Preschool Models
Kathleen Mahoney*, University of Massachusetts, USA
Jeanne Brunner*, University of Massachusetts, USA

ABSTRACT
This mixed method convergent survey design study looks at preschool educators' attitudes and perceptions of play-based science learning compared across public, Head Start, private, and forest preschools. Children learn about the world around them through play (Vygotsky, 1978) and science is the acquisition of knowledge about the world by using curiosity, learning, and play (Uluda_ & Erkan, 2023). Therefore, play-based science learning should be the focus of preschool education. Results from this study show most preschool educators report they use play to support science learning, but there are differences in attitudes and perceptions among each model. Throughout the survey, the forest school model was the only model that consistently linked play-based science learning with their model. The forest school educators approach play-based science learning from a holistic, inclusive, immersive practice that is fully and naturally integrated into their program. In contrast, the other models discuss challenges including finding the time and resources to support play-based science learning in their classroom. Results from this study bring to light the need to develop play-based science learning as a construct in hopes of increasing science and play opportunities in all preschool classrooms.

Rethinking Early Years Environmental Science Education, Pedagogy, and Approaches in Response to Climate Change
Peter Oyewole*, Kent State University, USA

ABSTRACT
Education needs to be reimagined to meet the environmental challenges of our time. This implies that environmental education should be grounded in environmental literacy, using multiple perspectives beyond human-centric to understand the interconnections between natural systems and human activities, leading to children developing a sense of ecological citizenship. Rethinking human interaction with the natural world. It is insufficient to rely only on knowledge and technology to solve our environmental problems. An "environmental

culture" that acknowledges the value of the natural world and our dependency on it is required to make sustainable decisions.

Head Start Teachers' Understanding of Science and How it Relates to Classroom Science Practices

Arianna Pikus*, Texas A&M, USA
Hope Gerde, Texas A&M, USA
Christina Schwarz, Michigan State University, USA
Kyung Sook Lee, University of Alaska Fairbanks, USA
Laurie Van Egeren, Michigan State University, USA

ABSTRACT
There has been a recent push in early childhood education to incorporate high-quality science experiences into the preschool classroom (NASEM, 2022). However, the field has skipped a critical first step in determining what ideas teachers already bring into their classroom about science. Teachers' ideas about science are an important area of study because research has shown teachers' ideas can influence their implementation of curriculum and classroom practices. Taking an asset-based approach, the current study qualitatively analyzes early childhood teachers' ideas about science and how these ideas relate to their classroom science practices. In this study, teachers' open-ended responses to these questions were analyzed qualitatively using thematic analysis (Braun & Clark, 2006). Overall, these ideas were shown to be more positive than previously found. A weak, but positive correlation was found between these ideas and other measures of teachers' attributes related to science (e.g., attitudes and beliefs about science and science self-efficacy). However, teachers' attributes about science were not shown to predict classroom science practices. This study highlights a need to figure out how to better support teachers in engaging children in science practices and the role that beliefs, contexts, practices, and other dimensions play in the process.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

SC-Organized Paper Set

Discourse-based Learning

17-Mar-24, 4:45 PM-6:15 PM

Location: Plaza Court 5

What Kinds of Argumentation Dialog Types are Useful?

Shuang Xu, East China Normal University, China
Xiao huang*, Zhejiang Normal University, College of Education, China
Sibel Erduran, Department of Education, University of Oxford,, United Kingdom
Mengzhuang Zheng, Zhejiang Normal University, China

ABSTRACT
Dialogic argumentation has been defined as a potential argumentation dialog and has been proposed as an effective pedagogical interaction that is close to the open-ended IRE that teachers are able to understand, develop, and practice in their daily teaching activities. Conceptualizing argumentation dialog is important for promoting argumentation in science teaching. We used the framework of argumentation dialog types exploited by Douglas Walton to examine12 transcripts of classroom teacher-student dialog to identify the argumentation types in Chinese science classes. We found that five types of dialogs were also presented in a natural classroom setting, and the proportion of each type was influenced by the content of the lesson. Of course, there are flaws in argumentation dialogs in a realistic classroom setting when teaching argumentation is not the main goal. The teacher has the ability to use talk moves to grasp the direction and progress of the classroom; these include "revoicing" moves, "marking" moves, "say more" moves, building opposing roles and giving the power of questioning to students.

Learning the Ropes: How Do Mentors Support Students Through the Scientific Publication Process?

Tanya Bhagatwala, Emory University, USA
Trisha Minocha, Emory University, USA
Sarah Fankhauser*, Oxford College of Emory University, USA

ABSTRACT
In the last two decades, research experiences for pre-college students have gone from the exception to a typical endeavor. Often, these research experiences include distinct disciplinary literacy outputs that mimic those of professionals. And while much attention has been paid to supporting students in scientific writing, other disciplinary literacy practices, such as peer-review and publication, are often part of the hidden-curriculum of science research, thus excluding students from fully understanding ways in which scientific knowledge is constructed, refined, and disseminated. As more students participate in research experiences and the dissemination of their work, it is important to understand how mentors support the development of disciplinary literacies, including those that are deemed professional. To this end, we used a mixed-methods study of interviews and surveys to examine the experience and conceptions of the mentors who guided precollege students through the writing and publication of their scientific research projects. Using the framework of cognitive apprenticeship to evaluate our findings, we find that although mentors highly value peer-review and publication within science, mentors tended to focus on providing mechanical support and less on helping students develop cognitive strategies, thus illuminating an area ripe for more investigation and professional development.

Using Questions to Reach Across Disciplines in a Middle School Integrated STEM Investigation

Lori Klukowski*, Middle Tennessee State University, USA
Ryan Jones, Middle Tennessee State University, USA
Fonya Scott, Middle Tennessee State University, USA

ABSTRACT
In integrated STEM investigations, students draw upon different disciplinary concepts and practices as they solve problems (Kelley & Knowles, 2016; Moore et al., 2020; Roehrig et al., 2021). Teachers need to guide student sensemaking using concepts and practices from multiple STEM disciplines, and to help students productively reach for ideas and practices from other disciplines as they solve STEM problems. When science teachers ask questions about disciplinary practices, concepts, and the phenomena or problem in the same lesson, they help students make sense of disciplinary practices (Benedict-Chambers et al., 2017; Colley & Windschitl, 2016; Fitzgerald & Palincsar, 2019)). However, little is known about how teachers' questioning strategies support students as sensemakers as they engage in integrated STEM investigations.
Here we describe how a middle school science teacher asked questions to help students draw upon ideas and practices from both science and mathematics classes to make sense of data in an integrated STEM investigation carried out in a science class. This study provides insight into new opportunities and challenges for teacher questioning when engaging in cross-disciplinary teaching.

Investigating Teacher Questioning During Scaffolded Lessons for Evaluating Alternative Scientific Explanations

Janelle Bailey*, Temple University, USA
Lorraine Ramirez Villarin, University of North Georgia, USA
Donna Governor, University of North Georgia, USA

ABSTRACT
Questioning is an essential action exercised in the science classroom to engage, assess, and encourage reflection within students. This descriptive study explores the types of questions teachers use to facilitate scaffolded lessons on competing models regarding extreme weather events. The research questions include (1) What kinds of questions do teachers ask to engage students in scientific argumentation for scientific evaluation?,(2) Are there differences in the use of question types across on-level Earth science and Advanced Placement (AP) science courses? Our population consists of four high school teachers from Southeastern US teaching on-level Earth science, advanced biology, or advanced environmental science. We used a framework from Erdogan and Campbell (2008) to classify teachers' questions within three major categories: closed-ended, open-ended, and task-oriented. Findings reflect a marked difference between the type of questions asked by the on-level teachers and those teaching an advanced curriculum, with the former using more task-oriented and closed-ended questions and the latter asking more open-ended questions. When looking at specific questioning sequences (i.e., back-to-back, closed-ended to open-ended), there is also an observable difference between on-level and advanced course teachers as the latter transition more frequently from lower to higher-order items.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set
Pedagogy in Science Museums
17-Mar-24, 4:45 PM-6:15 PM
Location: Plaza Court 6

When Science Museums Re-Imagined Their Communication and Educational Roles: Responses to the Covid-19 Pandemic
Ana Maria Navas Iannini*, Simon Fraser University, Faculty of Education, Canada
Erminia Pedretti, University of Toronto, Ontarion Institute for Studies in Education (OISE), Canada

ABSTRACT
This paper examines how science museums responded to the pandemic through online initiatives that sought public engagement with the topic of Covid-19. Informed by literature about generations of science museums and museums and Covid-19, we looked to understand what online education and communication programs and initiatives tell us about the contemporary social roles of these institutions. As such, we focused on case studies represented by the online programming of three science museums in Brazil, Canada and the U.S.: the Museu do Amanhã (Rio de Janeiro), the Royal BC Museum (Victoria), and the Museum of Science (Boston). The thematic analysis revealed renewed institutional values related to empathy, compassion and mindfulness. It also unravelled fourth generation commitments with allyship, epistemic democracy, and social transformation.

Learning Talk and Museum Signage at an Informal Science Exhibit
Jefferson Ramsey*, UNC Chapel Hill, USA
Leah Metcalf*, UNC Chapel Hill, USA
Slki Lim, UNC Chapel Hill, USA
Mengyi Mao, UNC Chapel Hill, USA
Janice Anderson, UNC Chapel Hill, USA
Jill Hamm, UNC Chapel Hill, USA

ABSTRACT
Contemporary sociocultural research has underscored the importance of visitor conversations for learning in informal contexts. Much of this research, however, focuses on how parents scaffold their children's learning or how museum staff can enhance visitor experiences (Callanan et al., 2017; Scalfi et al., 2022). The extant literature remains unclear about the nature of conversations between young adolescents in these settings or how built-in exhibit scaffolds might facilitate those conversations. Using Allen's (2002) learning talk framework, this design-based research study examines the interactions between middle school students and their use of signage at an informal science exhibit. The findings herein suggest that particular elements of exhibit signage may promote more frequent conceptual engagement with exhibit content.

Dual Role Science Museum Educators: Fun = Engagement = Learning
Patricia Patrick*, Columbus State University, USA
Monique Lester, Columbus State University, USA

ABSTRACT
Formal and informal science education are separate communities of practice (CoP) with the systems overlapping as needed. However, there is a third CoP that is not well researched. Full-time formal classroom educators who work part time in informal science learning centers. We term a full-time formal science educator who works part-time as an informal science educator—dual role science educator (DRSE). The DRSE take on the role of informal science educators. We completed an exploratory case study of a DRSE CoP at the Museum Learning Loft (pseudonym) to examine the epistemological and pedagogical beliefs of four DRSE. Using open coding, we discovered five themes: (1) teacher role, (2) instruction, (3) when students learning, (4) different from the classroom, and (5) resources/supplies. All four DSRE mentioned these themes and subthemes. DRSE (1) described their role at the Museum as facilitating, planning, and supporting learning, (2) believed they were better trained and more knowledgeable than the full-time Museum educators, (3) mentioned teaching and learning was more fun in the Museum, (4) determined instructional time was different, (5) felt less stress in the Museum classroom, and (6) thought it impossible to teach the same concepts in their formal classroom.

Revisiting Distance Learning in Museums Three Years After Covid-19 Closures
Megan Ennes*, University of Florida, USA

ABSTRACT
With the onset of COVID-19 in 2020, museums around the world turned to online programming to remain connected with their audiences. Understanding how museums are continuing to engage in distance learning programs can help researchers identify opportunities to engage in research related to these programs. This study is a follow up to two surveys conducted in 2020 and 2021 documenting current practices in museum-based online learning. A survey was sent through professional listservs and 100 respondents completed the entire survey. The survey included questions about the development and facilitation of online programs in museums. It also included 11 new questions about educators' levels of self-efficacy to teach online as well as questions asking how their programs have evolved since 2020. The findings in this study were similar to those from prior to museum closures in 2020 as well as the findings from one year after museum closures. This suggests the field has stabilized in program development since the onset of the pandemic when educators had to quickly pivot their programs online. In addition to the findings, this manuscript offers recommendations for future research related to online programming in museums.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Approaches of Preservice Teachers Developing Self-efficacy for STEM Learning and Teaching
17-Mar-24, 4:45 PM-6:15 PM
Location: Governor's Square 16

Exploring Preservice Teachers' Computational Thinking (CT) and Self-Efficacy through Scaffolding Plugged and Unplugged CT Activities
Jeffrey Radloff*, SUNY Cortland, USA
Bridget Miller, University of South Carolina, USA

ABSTRACT
Current STEM reform promotes integrating computer science (CS) and computational thinking (CT), meaning teachers must recognize CS as a set of discrete ideas, practices, and careers. Yet, teachers are often found to be unfamiliar with CS and CT, meaning they need access to effective professional learning opportunities that support their related understanding and promote increased self-efficacy. The use of 'plugged' and 'unplugged' CS activities can be employed alone or in combination to meet these goals. The current study explores a series of scaffolded 'plugged' and 'unplugged,' environmentally-focused and robotics-based CS activities used to support preservice elementary teachers' (PSTs') CS understandings and self-efficacy. Participants included 43 PSTs enrolled in an ed-tech content course in the final year of their teacher preparation program at a northeastern teaching college. Data included responses to pre-and post-surveys, lesson reflections, PST-created robotic activity mats, and challenge briefs. All artifacts were analyzed using open coding and descriptive statistics. Findings revealed that the combination of 'plugged' and 'unplugged' activities supported PSTs' CS understandings and self-efficacy, and reflections provided insights into when and how these shifts took place. Results provided concrete directions and entry points for further STEM teacher education and research.

Development of Integrated STEM Teaching Self-Efficacy Among Elementary Preservice Teachers
Jeanna Wieselmann*, Southern Methodist University, USA
Deepika Menon, University of Nebraska - Lincoln, USA
Sarah Haines, Towson University, USA
Sumreen Asim, Indiana University Southeast, USA
Amanda Koch, Independent Contractor, USA
Derek Cox, University of Nebraska - Lincoln, USA

While STEM disciplines have traditionally been taught as distinct subject areas in formal educational settings, K-12 standards are rapidly shifting toward integrated STEM (iSTEM), which seeks to merge the STEM disciplines to prepare students for careers that require interdisciplinary knowledge. iSTEM teaching self-efficacy remains under-researched, so little is known about how to support preservice teachers' self-efficacy development within iSTEM

contexts. Focusing on elementary preservice teachers' experiences in STEM methods courses, this mixed methods study explores the research questions:

1. How does preservice elementary teachers' iSTEM teaching self-efficacy change during their participation in semester-long STEM methods courses?
2. What sources of self-efficacy within the STEM-focused semester influence preservice teachers' beliefs and confidence about teaching?

Using a triangulation convergent mixed methods design with 211 participants across three institutions, findings from this study demonstrate that elementary preservice teachers experienced growth in iSTEM teaching self-efficacy through their STEM methods coursework. Further, qualitative findings highlight the relative importance of different types of experiences that participants described as impacting their knowledge and confidence related to iSTEM instruction, moving beyond documenting that changes in self-efficacy occurred to consider how and why these changes arose.

Investigating Preservice Elementary Teachers' STEM Teaching Self-Efficacy and Goal Orientation

Derek Cox*, University of Nebraska-Lincoln, USA
Deepika Menon, University of Nebraska-Lincoln, USA
Jeanna Wieselmann, Southern Methodist University, USA

ABSTRACT

Science, technology, engineering, and mathematics (STEM) instruction is highly emphasized in elementary classrooms in order to develop the next generation of STEM professionals. While reform efforts have focused on re-designing preservice teacher preparation courses, there are many factors that affect elementary preservice teachers' (PSTs') abilities to teach STEM. Self-efficacy stands as a pivotal factor impacting a teacher's motivation and performance. Consequently, fostering the development of integrated STEM teaching self-efficacy among PSTs becomes imperative. At the same time, goal orientation has an impact on PSTs' learning behaviors in order to accomplish goals related to future STEM teaching. This mixed methods study aims to explore the changes in PSTs' STEM teaching self-efficacy and goal orientation, the relationship between the two constructs, and the experiences of the PSTs that influence their confidence and views of STEM instruction in a semester-long STEM methods course. The data were collected using Self-Efficacy for Teaching Integrated STEM and goal orientation surveys, and semistructured interviews. Data analysis included paired sample t-test, correlational analysis, and thematic analysis to generate findings. The findings revealed a significant change in both self-efficacy and goal orientation. Implications for preservice teacher preparation are discussed.

Assessing Preservice Teachers Understanding of Computational Thinking using Science Lesson Plans

Line Saint-Hilaire*, Queens College, CUNY, USA
Anna Malyukova, Queens College, CUNY, USA

ABSTRACT
Computational thinking (CT) has gained considerable recognition in education in recent years. CT places a combined emphasis on problem-solving by the learners; and the articulation of solutions which learners can convey to others toward replication. When considering young children learning CT concepts, we need to also consider teachers' knowledge of computational thinking. Therefore, instructors in education programs need to equip teacher candidates with such skills for them to meet the growing demand of development of students' digital literacy. This case study reports the assessment of the understanding of preservice teachers (PSTs) of computational thinking and their ability to design CT integrated science lesson plans from experience with unplugged CT activities in a science methods course at a public university. Our findings indicate that the PSTs understand and can describe the main components of CT but struggled with the integration of CT components, particularly using inquiry-based instruction.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Science Teachers' Identity Development
17-Mar-24, 4:45 PM-6:15 PM
Location: Directors Row J

Science Teacher Identity Research: A Scoping Literature Review
Xiufeng Liu*, University at Buffalo, State University of New York, USA
Yanfang Zhai, Capital Normal University, China

ABSTRACT
Science teacher identity significantly influences teacher professional development, practices, and attitudes, which in turn impacts student learning outcomes. While there have been an increasing number of studies on science teacher identity in the past two decades, the most recent comprehensive review on this topic dates back a decade ago; there is a need for an updated systematic literature review. This systematic literature review aims to map out current state of science teacher identity research and identify possible future research directions. This scoping literature review identified 49 papers published between 2000 and 2023 on science teacher identity and examined these studies in terms of (a) characteristics of research studies; (b) theoretical framework utilized in research studies; (c) definitions of science teacher identity; and (d) the major findings of research studies. This scoping review identifies both progress and gaps in the current literature and presents future research directions. There is a particular need for valid, reliable, and fair instruments to capture the relatively stable facets of science teacher identity at a given moment in a given context in order to track its longitudinal change. This review provides a springboard for more productive and significant future research studies on science teacher identity research.

Examining the Role of Instructional Coaching on Elementary Teachers' Science Teacher Identity Development
Dionne Cross Francis*, University of North Carolina, USA

Andrea Phillips*, Indiana University, USA
Anina Mahmud*, University of North Carolina, USA
Meredith Park Rogers*, Indiana University, USA

ABSTRACT
Given the connection between a teacher's identity and their instructional practices, exploration of science teachers' professional identity has gained traction within the last two decades. However, despite the connection between identity and instruction, many professional development programs focus exclusively on developing teachers' pedagogical content knowledge without considering their identity development. Teacher identity development necessitates an iterative cycle of action and reflection which is essential for teacher growth and development. Instructional coaching is the kind of professional development that facilitates the reflexive transformation essential to identity development. Using a single item identity measure, we explored teachers' science identity development, and the factors underlying their perceptions, as they participated in instructional coaching that foregrounded holistic support and reflection on their instruction. We observed positive shifts in elementary teachers' science identity development. Factors that supported these positive shifts aligned with Carlone and Johnson's (2007) dimensions of science identity development. We discuss implications for teacher professional development.

Being Science Teachers: Co-Constructing Identities In Science Instructional Coaching Conversations
Catherine Bhathena*, Indianapolis Public Schools, USA

ABSTRACT
Research on coaching has increased over the last few decades, particularly for literacy and math. What is limited in coaching research is investigations of the process that leads to teacher and student impacts, especially in science. Additionally, while some research has investigated what makes an effective coach, little has focused on the specific roles of discourse and identity in changing instructional practices. In this comparative case study, I analyze the identity discourses of teachers and an instructional coach to investigate the interplay between identities and how identities and instructional practice are intertwined. The research question guiding this study is How do science teachers and a coach co-construct identities in coaching conversations focused on changing instructional practices to benefit multicultural/multilingual learners? Findings in this study include that 1) teacher identity is inseparable from teacher learning, 2) coach identity is inseparable from coach learning, and 3) the interplay of coach and teacher identities impacts coaching conversations. My findings here support the need for more theorizing and research on coaching, especially in science. My findings also indicate the need for intentional coach professional development focused on coach identity development and understanding of how identity is intertwined with effective professional development in science.

Exploring Elementary Teaching Efficacy Differences Between Life and Physical Science
Doug Ball*, Utah State University, USA
Colby Tofel-Grehl, Utah State University, USA

ABSTRACT
Science teaching efficacy is a critical predictor of instructional methods, teaching engagement, and pedagogical choices in science education. However, elementary teachers tend to have lower science teaching efficacy in physical science than in life science, which can lead to less effective teaching practices in physical science. Given the need to increase teachers' science teaching efficacy to improve their science teaching practices, this study examined how in-service elementary teachers' disciplinary science teaching efficacy beliefs differ between physical and life science. This was done by developing and using an adapted Science Teaching Efficacy Belief Instrument (STEBI) survey to measure the specific differences in efficacy beliefs between disciplines. The findings of this study show that elementary teachers do not believe they have the skills and knowledge to teach physical science as effectively as life science. Additionally, elementary teachers are less confident in answering student questions and monitoring student experiments in physical science than in life science.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Teachers' Content and Pedagogical Content Knowledge
17-Mar-24, 4:45 PM-6:15 PM
Location: Directors Row H

Unraveling Empirically Supported Factors Contributing to Pedagogical Content Knowledge Development: A Systematic Analysis of Literature
Soonhye Park*, North Carolina State University, USA
Kennedy Chan*, The University of Hong Kong, Hong Kong

ABSTRACT
This systematic literature review aimed to compile factors influencing changes in Pedagogical Content Knowledge (PCK) as identified in research conducted in natural or experimental settings involving interventions. It also sought to analyze trends and methodological approaches in this research domain. Ninety-nine empirical studies published from 1986, when PCK was introduced, to 2023 were included based on specific criteria. Analysis employed a coding scheme built upon an initial framework derived from existing PCK development reviews. The review revealed key factors contributing to science educators' PCK growth, including authentic teaching experience, professional development programs, and teacher education courses. Detailed examination of these factors highlighted that, while PCK naturally develops through teaching experience within authentic classroom environments, pre-service teachers' PCK-readiness and practicing science educators' PCK development can be accelerated through purposefully designed teacher education courses and targeted PD programs. Moreover, significant disparities emerged in the conceptualization, operationalization, and measurement of PCK, potentially contributing to the lack of well-established theoretical underpinnings grounded in robust empirical support within PCK research. To facilitate the amalgamation of findings across diverse studies for

construction of meaningful and coherent explanations for PCK development, researchers are encouraged to collaborate and establish a consensus on methodological approaches to research on PCK.

A model for developing teachers' Contemporary Content Knowledge (CCK)

Ron Blonder*, Weizmann Institute of Science, Israel

ABSTRACT

Science knowledge keeps developing and building up through research, whereas the science curriculum is generally stable and remains almost static over the years. By understanding and navigating through this tension, teachers can effectively bridge the gap between the two realms and enhance their professional growth. This study presents a model developed to support the development of teachers' Contemporary Content Knowledge (CCK) and demonstrates its stages in different teacher courses. This model empowers teachers to learn contemporary science by learning contemporary science and by (1) critically analyzing its feasibility in the existing curriculum, (2) designing lessons for their students when they learn this new science, and (3) assessing student learning. The rationale behind each part of the model is detailed. We have evidence that implementing the model supports the development of teachers' personal CCK and skills; hence, it improves their teaching of chemistry. This research contributes to theory by adding the CCK component to teachers' PCK; moreover, it examines CCK's contribution to teachers' PCK, and a model is designed for its development.

Mapping the Development and Deployment of Teachers' PCK and Instructional Practices After Modeling Instruction PD

Matt Reynolds*, North Carolina State Univeristy, USA
Laura Chalfant, North Carolina State Univeristy, USA
Grace Carroll, North Carolina State Univeristy, USA
Elsun Seung, Indiana State University, USA
Soonhye Park, North Carolina State Univeristy, USA
Amanda Hall, North Carolina State Univeristy, USA
Elizabeth Kluckman, North Carolina State Univeristy, USA
Scott Ragen, North Carolina State Univeristy, USA
Jason Painter, North Carolina State University, USA

ABSTRACT

This study investigated changes in pedagogical content knowledge (PCK) and use of science and engineering practices (SEPs) among a cohort of biology teachers after participation in a Modeling Instruction (MI) professional development program. The study employed a longitudinal, multiple-case study approach, utilizing a variety of data sources, including PCK mapping, to elucidate changes in the teacher's professional knowledge and science instructional practices as they implemented MI. The results revealed the participating teachers demonstrated more sophisticated PCK by integrating a greater number of components in each PCK episode by the end of the MI implementation year. The relationship between teachers' knowledge of students' understanding and knowledge of instructional

strategies was a prominent and consistent aspect of their PCK. Evidence suggests the teachers' integration of knowledge of curriculum played a pivotal role in shifting their PCK and instructional practices. As a cohort, increases were observed in both the total number of PCK connections and science instructional practices. However, a discrepancy between reported practices and classroom observations suggests the influence of other factors, such as teachers' beliefs. This study highlights the complexity of teachers' PCK development and the integration of SEPs, contributing to the understanding of teacher professional development in science education.

Personal and Enacted PCK for Teaching Earth Science: A Case Study of an Elementary-School Teacher

Claudia Vergara*, Universidad Alberto Hurtado, Chile
Kasandra Navarrete, Universidad Alberto Hurtado, Chile
Carolina Cartes, Universidad Alberto Hurtado, Chile
Hernan Cofre, Pontificia Universidad catolica de Valparaiso, Chile
Paola Nuñez, Pontificia Universidad catolica de Valparaiso, Chile

ABSTRACT
Teaching of geoscience in the world faces multiple difficulties. Therefore, the achievement of students' scientific literacy in this subject depends to a large extent on what the teachers who must teach these contents at school can do. In this context, it is essential to develop the PCK of teachers on this topic. This study describes geoscience PCK in action and on the action of a primary teacher who received training on geoscience and teaching it, and relates these two types of PCK. Through the application of a CoRe interview before and after carrying out 8 lessons on geoscience, the PCK on the teacher's action was described. The PCK in action is described through a detailed analysis of the 8 lessons through an observation guideline. The results show that the teacher develop his declarative PCK mostly about the knowledge of students learning, including more alternative conceptions and challenges of learning and the knowledge about the curriculum, realizing the challenges of teaching the content and handle all subject matter concept. The in action and on action PCK is coherent in terms of the strategies used and declared and also because his teaching is centered on the students, who work collaboratively in groups.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set
Families Matter: Family Learning as a Central Component to Equity in STEM Education
17-Mar-24, 4:45 PM-6:15 PM
Location: Governor's Square 14

Recognizing Black Family Members as Partners in STEM Education

DeLean Tolbert Smith*, University of Michigan-Dearborn, USA
Monica Cardella*, Florida International University, USA

ABSTRACT
Black Families are vital agents of STEM education, yet there is a limited understanding of the impactful ways the family members together explore and encourage STEM knowledge. In this study, we explored the experiences of 125 Black 6th grade aged youth and two Black families as they completed an engineering design activity during an after-school STEM night. The research team conducted three separate school visits to facilitate and test the activities with (~200) Black 6th-grade aged (10-12 years) youth, facilitated an engineering design session with three families during an after-school family STEM Night, and 12 families participated in session at an Innovation Museum. This work demonstrates that Black families have an active role in their students' STEM learning and application experiences. Through this work, we begin to identify how family members serve as critical agents in STEM learning through actions such as: working on engineering-type projects at-home, encouraging problem exploration, following the invention process, and celebrating ideation. The inclusion of family members as STEM co-learners and supporters helps us to advance equity by thinking about the whole child and their full context for learning.

Considering the Family-Centric STEM Identity Development Model to Support Inclusivity in Designing STEM Learning Experiences

Remy Dou*, Florida International University, USA
Heidi Cian, MMSA, USA

ABSTRACT
Inspired by research on engineering interest development as a systems-based phenomenon, we consider STEM identity development in the context of family systems. We conducted a longitudinal multi-case study of three families (i.e., primary caregivers and children) to explore families' STEM related discourses. We invited families to participate in a series of five interviews and two video recordings of engagement in STEM related activities. We attended to the social circumstances in which children and caregivers describe developing and expressing their STEM identities to study how development appeared to co-occur with social partners. We found that caregivers made use of three primary approaches to shape children's identification with STEM by defining the boundaries of STEM (i.e., what/who constitutes STEM and/or related disciplines) while simultaneously positioning their children within or outside of those boundaries. Collating our themes, we make the case for examining children's STEM identity development as an inextricable factor of their familial milieu, presenting Family-Centric STEM Identity Development (FSID) as a conceptual framework that closely attends to family-related factors shaping children's identification with STEM fields.

Agentic Interest Pathways: Understanding How Families Shape Their Own Interest Development to Inform STEM Equity

Scott Pattison*, TERC, USA
Smirla Ramos Montañez*, TERC, USA
Viviana López Burgos, TERC, USA
Gina Svarovsky, University of Notre Dame, USA
Annie Douglass, Oregon Museum of Science and Industry, USA

Julie Allen, Mt. Hood Community College Head Start, USA
Catherine Wagner, University of Notre Dame, USA

ABSTRACT
In STEM education, the goals of families are almost universally positioned as secondary to the goals of educators and researchers. In this paper, we propose a new framework (agentic interest pathways) for thinking about family STEM-related interest development that centers the goals of families and highlights the ways that they demonstrate creativity, resourcefulness, and agency in leveraging STEM learning experiences to support these goals. Through longitudinal qualitative case study research, we explored the experiences and perspectives of 12 English- and Spanish-speaking families who had participated in a 6-month family-focused early childhood engineering education program. Data collection involved parent/caregiver interviews throughout the program; participant observations and documentation of program events; and videos, pictures, and reflections from family engineering engagement at home. Findings highlighted how families entered the program with a variety of goals and motivations that evolved over time through their experiences with the program. Most importantly, the analysis demonstrated the creativity and resourcefulness of families in leveraging and adapting different program components to support their goals. These findings can guide efforts to design learning opportunities inside and outside of school that meaningfully advance the goals of families and communities as part of a more just STEM education system.

STEM Fam: Fostering Rightful Familial Presence in Middle School STEM
Angela Calabrese Barton*, University of Michigan, USA
Edna Tan, University of North Carolina at Greensboro, USA
Wisam Sidawi, University of Michigan, USA
Francisco Para Camacho, University of Michigan, USA
Virginia Swindell, University of North Carolina at Greensboro, USA

ABSTRACT
A macro-structural inequality in STEM education for youth of Color is how parents/families are valued in school settings. Most models of parental/familial involvement are rooted in White, middle-class power structures that reproduce racial/class inequalities, and obscure familial social/cultural capital. This study investigates research and instructional practices that support rightful familial presence in STEM to address this challenge. This study is grounded in the Rightful Presence and the Community Cultural Wealth Frameworks. We define rightful familial presence as a form of authentic family engagement that legitimizes families' community cultural capital and fosters capital movement between families and schools, especially when these forms of capital have historically been marginalized within STEM learning. Drawing upon DBIR with researchers, teachers, parents, and youth in two urban school districts, we enacted the "STEM FAM" project, through collaborative activities across a semester. We describe two practices that created spaces for authoring familial presence in STEM learning, even when parents were not physically present during classroom enactments: Rooting/tending to emergent STEM epistemologies in familial values/wisdom & Storying ourselves into STEM. We discuss tensions in these change-making efforts, in relation

to shifting normative practices/perspectives of parental engagement and familial capital in STEM.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Identity and Gender: Student Portraiture, Teacher Perspectives, and Pursuing Equity
17-Mar-24, 4:45 PM-6:15 PM
Location: Governor's Square 12

Meaningful Classroom Engagement for Cultivating STEM Identity: Exploring High School Student Perceptions Through Portraiture
Elizabeth Saville*, UBC Okanagan, Canada

ABSTRACT
This qualitative study uses a portraiture methodology to examine how high school students understand their experiences in science, technology, engineering, and math (STEM) classrooms to have supported their identity construction in STEM. Portraits developed through this research capture diverse stories of student sense-making in STEM classrooms which bring to life thematic findings highlighting how participants (n=56) perceive their experiences in STEM classrooms as influential in shaping their sense of belonging and identity in STEM. Data collected through focus groups revealed three themes, each representing distinct forms of meaningful classroom engagement that contribute to fostering perceptions of identity and belonging in STEM including: Meaningful Personal Engagement, Meaningful Social Engagement, and Meaningful Curricular Engagement. Thematic findings and the narrative portraits developed through this research can offer educators valuable insights into how students shape identities in STEM both within and through their experiences in STEM classrooms. Furthermore, portraits developed through this research reveal broad, equity-based supports for those participating in STEM, which can be practically applied by educators as they work to create more equitable cultures of learning in their classrooms and decolonize practices and discourses in STEM education.

Using Storied Identities to Uncover Science Teachers' Identities in Science After an RET
Suzanne Patzelt*, Touro University, USA

ABSTRACT
RETs are regarded as the gold standard for science teacher professional development, giving teachers experiences with the practices of science. By partnering science teachers with scientists, they take on apprenticeship roles and gain experience in science. This paper focused on one participant from a larger study centered around uncovering science teachers' perspectives of the NOS both prior to and after their participation in an RET, as well as how different experiences shaped their identities. I used narrative inquiry to collect teacher stories and critical frameworks to organize and present their storied science

identities. Denise's storied science identity highlights an important finding related to female identifying science teachers, and more generally, those who identify as female in science spaces. Despite Denise's confidence in the skills required for her different careers and experiences in science, her language choices reflected that of an outsider in science spaces. This study highlights the need for RETs and other science teacher PD programs to be more intentional in the ways they present science to their participants, such as the gendered language they use and the ways they do or do not foster a sense of belonging in science for participating teachers.

Gender Difference in the Attitude of Students to Computer Studies: Can CTCA Bridge the Gap?

Chinyere Ikpah*, Lagos State University-ACEITSE, Nigeria
Rasheed Sanni, Lagos State University-ACEITSE, Nigeria
Peter Okebukola, Lagos State University-ACEITSE, Nigeria
Deborah Agbanimu, National Open University of Nigeria, Nigeria
Franklin Onowugbeda, Lagos State University-ACEITSE, Nigeria

ABSTRACT

This study investigated the effectiveness of the Culturo-Techno-Contextual Approach (CTCA) in enhancing both male and female students' attitudes toward computer studies. Participants consisted of 157 junior secondary school students from two specifically chosen schools in Lagos State Education District V. Quantitative information was gathered using the reliable (0.94) Networking Attitude Questionnaire (NAQ) exam. For the purpose of collecting qualitative data, students were chosen at random from the experimental group. To ascertain the students' entry level, a pre-attitude exam was administered to all 157 of the students utilized in the experimental and control groups. The pre-test exercise was followed by four weeks of the treatment. Students in the experimental group received four weeks of teaching using CTCA. With the exception of CTCA components, the control group of students ($n = 99$) learned in the same manner as the experimental class. At the end of the treatment phase, all the students were given a post-attitude test on the same evaluative attitude instruments. Results on the ANCOVA output showed a statistically significant difference in the attitude measure [$F (1, 155) = 0.08$; $p<=0.78$]. Within limitations of the study, it is recommended that CTCA is capable of improving attitude of students in computer studies.

Towards Gender Equity in Science Learning and Achievement: Measuring the Catalytic Effects of Culturo-Techno-Contextual Approach

Adekunle Oladeje*, Lagos State University, Nigeria
Peter Okebukola, Lagos State University, Nigeria
Juma Shabani, University of Burundi, Burundi
Ibiyinka Ogunlade, Ekiti State University, Nigeria
Ademola Ibukunolu, Lagos State University, Nigeria
Deborah Agbanimu, Lagos State University, Nigeria
Franklin Onowugbeda, Lagos State University, Nigeria

ABSTRACT
As societies become increasingly concerned about the different forms of inequities which continually shape the chances people have in life, science education communities hold a responsibility to revamp the situation within the context of science teaching and learning. This project explored the potency of Culturo-Techno-Contextual Approach (CTCA) in levelling the playing field while promoting meaningful chemistry learning among male and female students. Two separate studies were conducted on two perceived difficult topics in chemistry. Participants for each study were drawn from two schools, purposively selected within Lagos State Education District V. In each study, the experimental groups were taught using CTCA, while the control groups were taught with lecture method. The research design was explanatory sequential using a pretest, posttest, post-posttest framework. Two instruments were used for data collection. Nuclear Chemistry Achievement Test and Achievement Test in Electrochemistry had reliability coefficients of 0.83 and 0.76 respectively. ANCOVA was used to analyse quantitative data, while the qualitative data was through framework analysis. The studies found no significant difference in the achievement (post-posttest) of the male and female students in the experimental groups. Hence, within the study limits, we concluded that CTCA has the potential to bridge gender-based differences in chemistry learning.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set
Concerns of Using Technology in Science Education
17-Mar-24, 4:45 PM-6:15 PM
Location: Governor's Square 15

The Use of Educational Technology in Inquiry-based Elementary Science Education: A Systematic Review
Minji Yun*, University of Florida, USA
Kent Crippen, University of Florida, USA

ABSTRACT
Technology has arisen as a powerful tool for enhancing students’ learning and engagement in science education, particularly in the context of elementary inquiry-based science education (IBSE). This systematic review examines the use of technology in IBSE over the past decade, analyzing 22 empirical studies to identify research trends and explore how technology has been employed. The study reveals that technology has mainly been used to support students' observation and data interpretation skills during the investigation phase of inquiry. However, it also indicates that technology has the potential to support other science process skills in other phases of inquiry. Furthermore, the analysis suggests research gaps in terms of the use of emerging technology and insufficient attention paid to employing technology to support students' modeling processes and simulations. These findings point to the need for further investigation to fully explore the potential of technology in supporting students' learning and engagement in elementary IBSE.

Is Classroom Technology Centering Students? A Review of Research on Digitally-Mediated Science Instruction from 2012-2022

Tess Bernhard*, University of Pennsylvania, USA

ABSTRACT

In this paper, I present a review of 72 empirical studies of digitally mediated science instruction in U.S. classrooms since 2012. In this era, two parallel reforms promoted visions of student-centered instruction: the Next Generation Science Standards (NGSS) and the rise of 1:1 devices in classrooms. I analyzed what instructional interactions studies foregrounded, how they were characterized, and whether they aligned with the NGSS. I found that studies tended to focally describe teachers' interactions with devices, while human-to-human interactions, particularly students' interactions with each other, were understudied. In particular, I find that a third of these studies lack description of students' engagement in science and engineering practices. Studies were instead preoccupied by two prominent, but misleading characterizations: teachers' lack of technological pedagogical content knowledge (TPACK), and students' natural proclivity toward technology as digital natives. Both characterizations obscured the ways that across studies, digitally mediated instruction was shaped by the larger communities and infrastructures of schools. To conclude, I call for research designs and professional learning opportunities that honor the ways teachers work alongside students and their school communities when adding digital layers to their instruction, and I caution against narrowing the aims of digitally mediated science instruction.

Towards Integrating Computational Agent-based Modeling Practices with Three-dimensional NGSS Learning

Aditi Wagh*, MIT, USA
Luke Conlin, Salem State University, USA
Daniel Wendel, MIT, USA
Emma Anderson, MIT, USA
Ilana Schoenfeld, MIT, USA

ABSTRACT

Over the last two decades, computational modeling has gathered much attention for how it can support multiple scientific and computational practices. Studies have shown that building, testing and using computational models supports learning of scientific concepts. However, not much work has been done to examine how these multiple computational modeling (CM) practices align with the scientific and engineering practices (SEPs) in the Next Generation Science Standards (NGSS). Drawing on existing literature, this theoretical paper puts forth a conceptual framework to align five CM practices with SEPs in NGSS. This framework has been developed as part of a Researcher Practitioner Partnership (RPP) between a public school district and two universities called NAME. The NAME project aims to develop curricula that integrate 3-Dimensional NGSS learning with computational modeling curricula for high school classrooms in four science subjects. We describe our design process using the framework and provide one example of a high school Physics curricular unit to illuminate the framework. Finally, we recommend directions for future research and discuss some of the design tensions in doing this work.

Supporting AI literacy in K-12 Science Education: Raising Critical Consciousness towards Ethical AI

Selin Akgun*, Michigan State University, USA
Hee Rin Lee, Michigan State University, USA
Kahyun Choi, Indiana University Bloomington, USA
Joseph Krajcik, Michigan State University, USA

ABSTRACT
Artificial Intelligence (AI) has brought drastic change to science and STEM education within the integration of personalized learning, automated assessment systems, and predictive analytics. Although AI holds considerable promise to give students individualized and timely feedback and reduce teachers' workload, the discourse towards ethical and societal challenges of AI simultaneously grows. Therefore, researchers and practitioners of science education needs to reflect empirically more on how to support elementary students' AI literacy using the critical and asset-based approach. With that goal, we aim to investigate a) what pedagogical approaches and modules can be developed and used to teach about core concepts and macro-ethical issues of AI in K-12 STEM education, and (b) how the implementation of these modules might support students' critical AI literacy. Using participatory design methodology, we conduct workshop series to help students in utilizing their own community-based assets when co-designing ethical AI technologies. During the workshops, we introduce two modules that we created to support students' foundational knowledge and critical thinking towards the ethical AI. The study will contribute to growing body of AI and science education research by articulating future directions and recommendations for teacher educators and practitioners of science education.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set
Knowledge Into Practice
17-Mar-24, 4:45 PM-6:15 PM
Location: Plaza Court 1

Specifying the Refined Consensus Model: An Argument for Biology-Specific Collective Pedagogical Content Knowledge

Sophie-Luise Müller*, Freie Universität, Germany
Daniela Mahler, Freie Universität, Germany

ABSTRACT
This proposal advocates for specifying the Refined Consensus Model of Pedagogical Content Knowledge by proposing arguments for a biology-specific Collective Pedagogical Content Knowledge (cPCK), underpinned by a theoretical review of literature in the philosophy of biology. This theoretical review identifies six distinct characteristics inherent to the scientific discipline of biology in comparison to other sciences (e.g., physics or chemistry) and represents the thought style of biology. This thought style is proposed as an essential

benchmark for a discipline-specific and contextually relevant cPCK tailored to biology education. The identified characteristics encompass the irreducibility of biological systems, the variability of biological systems, the openness of biological systems, the influence of chance events on biological systems, the irreversibility of biological systems, and the double role of researchers in biology and their tendency for natural fallacies. Each characteristic is explored for its potential implications on the thought style of biology on an ontological, epistemological, and methodological level. This specified benchmark for cPCK serves as an initial stride in establishing a framework of biology-specific cPCK that closely mirrors the thought style of biology, enabling further research on cPCK in biology education.

PCK of NOS: Approach to the Collective PCK of Expert Biology Teachers in NOS Teaching

Paola Nuñez*, Pontificia Universidad Católica de Valparaiso, Chile
Claudia Vergara, Universidad Alberto Hurtado, Chile
Carolina Parraguez, Pontificia Universidad Católica de Valparaiso, Chile
David Santibañez, Universidad Finnis Terrae, Chile
Hernan Cofre, Pontificia Universidad Católica de Valparaiso, Chile

ABSTRACT

The study of PCK about the NOS focuses on how teachers can effectively teach their students about how science works, how science is conducted, and how science relates to society. In recent years, theoretical models have been proposed to identify the elements that constitute a teacher's PCK. The academic community has called on researchers to empirically test these models to contribute to the understanding of how PCK is captured and developed. In this context, this study aims to characterize the collective PCK about NOS of a group of teacher-researchers in NOS, considering that this cPCK was proposed in the latest theoretical model about PCK and there is still no data related to it concerning NOS. To achieve the goal, the CoRe interview was administered to 8 teachers with experience in teaching and researching NOS. The interviews were categorized used PCK models widely in the literature. The results of the generated cPCK for NOS were represented following the Authors' Pentagon model. The generated cPCK for NOS has 23 codes distributed across 5 categories. The categories with the highest frequency were knowledge of teaching strategies and knowledge of student comprehension. Additionally, the category with the least corresponds to knowledge about teaching orientations.

Pedagogy of Practice Approach to Teaching Nature of Science to In-Service Teachers

Anna Pshenichny-Mamo*, Technion – Israel Institute of Technology, Israel
Haya Ben Simon, Technion – Israel Institute of Technology, Israel
Dina Tsybulsky*, Technion – Israel Institute of Technology, Israel

ABSTRACT

Integrating the Nature of Science (NOS) effectively into science education remains challenging for teachers, mainly due to time constraints, limited resources, misconceptions about NOS concepts, and a lack of knowledge about impactful NOS teaching methods. As a result, there is growing acknowledgment of the need for teachers to undergo proper professional development to teach various aspects of NOS within science lessons optimally.

This study examined the outcomes of a professional development course, designed as a 'pedagogy of practice,' on in-service teachers' perceptions of NOS teaching. Through a qualitative analysis of teacher reflections, lesson plans, and semi-structured interviews, we found that the course significantly influenced teachers' perceptions of NOS teaching. Teachers reported adopting new methods and adapting existing ones to teach NOS effectively. The findings also document the teachers' evaluations of different teaching methods for NOS and showed that their preferred methods are based on storytelling. Overall, this study suggests that the 'pedagogy of practice' framework provides a valuable way to bridge the gap between theory and practice, and can give teachers the know-how they need to teach NOS well and contribute to teachers' professional development.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set
Climate Change Education
17-Mar-24, 4:45 PM-6:15 PM
Location: Governor's Square 11

Psychological Distance to Climate Change: Science Teachers' and Scientists' Use of Visual Representations

M. Gail Jones*, NCSU, USA
Julianna Nieuwsma, NCSU, USA
Rebecca Ward, NCSU, USA
Madeline Stallard, NCSU, USA
Kathleen Bordewieck, NCSU, USA
Amber Meeks, NCSU, USA
Tanzimul Ferdous, NCSU, USA
Kimberly Ideus, NCSU, USA

ABSTRACT

Twenty-five secondary teachers were shown 25 visual displays and asked to select five they would use in a climate change presentation. Teachers were interviewed about the rationale they used for their selections. The teachers' selections were compared to those of scientists reported in a previous study. Results showed that all the teacher participants built their selections on a pre-existing goal for their climate change instruction. The majority of the teachers, as well as scientists, examined psychological temporal dimensions (e.g., a past hurricane) of the selections to determine if the display would be relevant, as well as cognitive complexity of the display. Display accuracy was rarely mentioned as a selection criterion.

Children's Understanding of Climate Change

Mijung Kim*, University of Alberta, Canada
Qingna Jin*, Cape Breton University, Canada

ABSTRACT
With growing climate crises, there is a growing imperative for research on climate change education. This study addresses a gap by exploring climate change education among Grade 3-4 students, a demographic often overlooked in existing research. Employing a case study approach, we engaged seven students in activities to probe their understanding of climate change. The findings illuminated that these children possess an awareness of and concerns about climate change. Furthermore, their grasp of the conceptual dimensions of climate change exhibited a wide spectrum, encompassing misconceptions, evolving ideas, and sophisticated insights. Notably, collaborative engagement with peers emerged as a vital catalyst in advancing and refining their ideas, particularly those in the developmental phase. This research is of interest to educators seeking to cultivate environmental consciousness and critical thinking in young learners, empowering them to navigate future environmental challenges as informed global citizens.

Climate Superheroes: Impact of a STEAM Camp on Preschool Children's Ideas about Climate-Friendly Actions
Lisa Borgerding*, Kent State University, USA
Breanna Beaver, Youngstown State University, USA

ABSTRACT
Climate change is an urgent global environmental crisis that requires widespread action. Climate change education provides an opportunity to educate the citizenry about appropriate climate-friendly actions. The present study explored the impacts of a Climate Superheroes STEAM camp on preschool children's ideas about climate-friendly actions. The research employed a mixed methods experimental design approach including a quantitative pre/post test, qualitative activity prompts, daily field notes, and a post-camp parent survey through which parents provided information about what children said about the instruction. The sample included 27 children aged three through six and 11 of their parents. Findings indicate that preschool children made significant gains on their understanding of climate-friendly action and that using reusable materials, turning off lights when not in use, and gardening were actions readily understood by the children. Additionally, parents indicated that working with others to help the Earth, recycling, and turning off the lights when not in use were actions most often referenced at home. Children demonstrated many correct ideas about how and why climate-friendly actions helped the Earth and some common misconceptions as well. Implications for early childhood education and environmental education related to climate change are explored.

Developing a Model of Climate Change Literacy Based on the Systematic Literature Review
Helin Semilarski*, University of Tartu, Estonia
Helen Semilarski, University of Tartu, Estonia

ABSTRACT
Climate change is one of the key topics of science education (Carman et al., 2019) and sustainable development, where awareness of climate and education are crucial (Otto et al., 2019). The modern-day concept of climate change typically reflects environmental changes

brought about by anthropogenic involvement in the ecosystem (Jan et al., 2020). The main aim of this theoretical article is to come on consensus and to conceptualize the term climate change literacy (CCL) more clearly and to present a theoretical concept of CLL, composed on the basis of systematically analysed articles. Also to develop a climate change model.

Pre-Service Biology Teacher Beliefs about Climate Change Education
Veronika Winter*, University of Vienna, Austria
Andrea Moeller, University of Vienna, Austria
Alexander Buessing, Leibniz University Hannover, Germany
Niklas Gericke, Karlstad University, Sweden

ABSTRACT
To meet the challenges of climate change education (CCE), fostering teachers' professional development in this area is pivotal. Hereby, investigating influencing factors such as pre-service teachers' (PST) CCE beliefs is necessary to design teacher training settings that fit the needs of future educators. By drawing on previous work in environmental education and the Theory of Planned Behavior, this study aimed to investigate PSTs' normative, control and behavioral beliefs as well as self-efficacy for conducting CCE in the future and identify predicting factors forming those beliefs. We conducted a quantitative online study with 397 Biology PSTs from all Austrian universities, using established and newly adapted instruments. Results show that most PSTs agree on the importance of CCE and seem motivated to teach it in the future, but they scored low in believed support for doing so. Further, our analysis reveals that next gender, age, and teaching experience, PSTs' political ideology had the highest predicting ability on three out of five investigated CCE teacher belief sets, in line with previous studies. Data suggests for science teacher educators to consider intergenerational and gender-responsive approaches in CCE teacher training, as well as increasingly integrating CCE teaching practice and the political dimension of climate change.

Social Event
Early Career Faculty Institute Meet-up
17-Mar-24, 6:15 PM-7:00 PM
Location: Directors Row I

Early Career Faculty Institute Meet-up

ORGANIZERS
Julie Luft, University of Georgia, USA
Angela Calabrese Barton, University of Michigan, USA

ABSTRACT
This meet-up session is for early career NARST faculty (post-docs, faculty members in their first one-three years) and mentors who will be participating or who are interested in the inaugural NARST Early Career Faculty Institute. The purpose of the ECI is to support early-

career NARST members who are pre-tenured, or are in their first five years of academic work beyond their doctoral work.

Social Event
Presidential Welcome Reception and Dance
17-Mar-24, 7:00 PM-10:00 PM
Location: Plaza Ballroom ABC/DEF

---

18 MARCH 2024

Social Event
Mind & Sole Denver! "5280 - Let's Run Mile High!"
18-Mar-24, 6:30 AM-8:00 AM
Location: Off Site

Mind & Sole Denver! "5280 - Let's Run Mile High!"

ORGANIZER
Angela Calabrese Barton, University of Michigan, USA

It's back and better than ever! It's the 12th annual Mind and Sole 5K (almost) fun run/walk/stroll. This year we will hold the Mind & Sole on March 18, 2024 early in the morning (we'll aim to start at 6:30am), in downtown Denver, which is exciting as we have a beautiful run/walk/stroll planned out for you along the Cherry Creek Path just a couple of blocks from the hotel. Of course, you can complete the 5K at other times, but we will hand out shirts in the morning. If you are interested here is a couch to 5k (perhaps more accurate to say desk to 5k) that is 9 weeks long. And it's available in many languages, with versions for outdoor running/walking, treadmills, and even with your "pooch".
This event is neither affiliated nor sanctioned/sponsored by NARST.

RIG Business Meetings
18-Mar-24, 7:00 AM-8:00 AM

Asian and Pacific Islander Science Education Research [APISER] Business Meeting
Location: Governor's Square 17

Latino/a RIG [LARIG] Business Meeting
Location: Plaza Court 1

Contemporary Methods for Science Education Research Business Meeting
Location: Plaza Court 2

Engineering Education [ENE-RIG] Business Meeting
Location: Plaza Court 3

Indigenous Science Knowledge [ISK-RIG] Business Meeting
Location: Plaza Court 4

Research in Artificial Intelligence-involved Science Education [RAISE] Business Meeting
Location: Plaza Court 5

LGBTQ+ RIG Business Meeting
Location: Plaza Court 6

Continental and Diasporic Africa in Science Education [CADASE] Business Meeting
Location: Plaza Court 7

Interested in forming a Computational Thinking in Science Education RIG?
Location: Plaza Court 8

Roundtables Session 1
18-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Ballroom ABC/DEF

Colorado Science Education Research Roundtable
Supporting Computationally-Rich Science Instruction: Conceptual Models for CT-Integrated Science Curriculum and Professional Learning

Gregory Benedis-Grab*, CU Boulder, USA
Quentin Biddy, CU Boulder, USA
Srinjita Bhaduri, CU Boulder, USA
Jennifer Jacobs, CU Boulder, USA
Alexandra Gendreau Chakarov, CU Boulder, USA
Jeffrey Bush, CU Boulder, USA
Tamara Sumner, CU Boulder, USA

ABSTRACT
The development of computational skills and practices are called for explicitly in the Framework for K-12 Science Education and the Next Generation Science Standards. Compelling arguments exist for integrating computational thinking (CT) into mainstream science classes, providing an engaging and realistic context for students to develop these skills and engage with CT practices as they participate in scientific inquiry. The study described in this paper took part within the context of a multi-year research practice partnership, with the aim of generating curriculum and professional learning to support students' equitable exposure to high-quality CT-integrated disciplinary science instruction. The paper describes the study's progress toward two conceptual models: CT-integrated science curriculum and teacher professional learning to implement this type of curriculum. Based on the research team's experience developing and iterating on these models in the

partner school district and several others, they appear to hold promise for a wide range of teachers and learners, including those who are more and less familiar with NGSS, sensor technology, and CT or computer science. The paper concludes with recommendations for the field, in particular ways to promote teachers' expertise in this complex and demanding endeavor.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Roundtable

Dissecting Dialogue: A Proposed Integrated Framework for Analyzing Student Discourse in Science Classrooms

Benny Mart Hiwatig, University of Minnesota, USA
Abdi Warfa*, University of Minnesota, USA

ABSTRACT

Engaging student discussions in science classrooms are vital for deepening conceptual knowledge, honing critical thinking, and fostering a love for science. Several conceptual frameworks have been proposed in the literature to guide the implementation of student discourse in science classrooms, but they vary in their focus and scope. Additional efforts are needed to determine their effectiveness in promoting high-level discourse and supporting the development of scientific reasoning skills. To address these issues, this paper presents an integrated conceptual framework for student discourse in science classrooms. This framework, anchored on discourse moves, logical processes, cognitive strategies, and positioning/social structure, offers a comprehensive lens to dissect complex student interactions during scientific discussions. Discourse moves scaffold these interactions, logical processes formulate sound arguments, cognitive strategies empower critical thinking, and positioning reveals underlying power dynamics. By using this framework and examining the interplay among its components, instructors can better understand the intricacies of student discourse and use this understanding to guide their pedagogical practices. This framework not only holds promise to improve student discourse in science classrooms, but also serves as a beacon for educators, researchers, and policymakers striving to make science education truly universal --- thereby, elevating scientific literacy for every student.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies
Roundtable

Elementary Science Teaching: Toward the Goal of Scientific Literacy

Valarie Akerson*, Indiana Univesity, USA
Selina Bartels*, Valparaiso University, USA

ABSTRACT

One goal of science education is for teachers to shape scientifically literate students . This work begins with elementary school teachers. Scientific literacy is composed of three parts: content knowledge (e.g., astronomy, biology, chemistry, geology, and physics), nature of science (e.g., science as a way of knowing) and scientific inquiry (processes of how scientific knowledge is developed) (Roberts, 2008). It is key for elementary teachers to begin shaping

understandings of each of these components of scientific literacy early in a student's education. In this review we share research on elementary science teaching, beginning with science standards that have been developed worldwide, followed by elementary teachers' self-efficacy for teaching science, their conceptions and practices of teaching nature of scientific knowledge, scientific inquiry, science content knowledge, and inclusion of engineering and STEM in the elementary science classroom. As selection criteria, both authors conducted separate searches in the databases of their respective university libraries for peer-reviewed articles of research conducted in content area knowledge, science teaching, and field work, with associated subsections. We draw conclusions about the status of elementary science teaching and make recommendations for future research to improve elementary science teaching in the presentation.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

Civic Science: Developing Scientific Literacy for Marginalized Students through Community Engagement

E. Woo*, Michigan State University, USA

ABSTRACT

Increasing scientific literacy through out-of-classroom experiences such as community engagement provides opportunities for students to engage with various stakeholders that all play a role in "doing" science. This study aims to increase engagement and representation for Black, Indigenous, and People of Color (BIPOC) students in science education - and specifically environmental education - through exploring civic engagement. Connecting science to the real world through people, civic engagement provides opportunities for students to gain an understanding of why science matters and how it impacts individuals personally. Through an analysis of community engagement within the environmental field, this study highlights the impacts on BIPOC students by creating a sense of belonging and inclusivity within the scientific community. It also presents a framework for scientific civic engagement that can be utilized within classrooms to create a more inclusive environment. Through prioritizing relationship building, agreeing on boundaries, centering counter-narratives, showing up consistently, and reflecting thoughtfully, scientific civic engagement is an effective tool that can help increase scientific literacy while also increasing representation of BIPOC individuals in science.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Roundtable

Citizen Science as Means to Support Understanding of Cultural Heritage.

Zoubeida Dagher*, University of Delaware, USA

ABSTRACT

Citizen science, comprising practices that involve members of the public in contributing to science data collection and analysis, is being increasingly used to advance science education goals. This presentation focuses on identifying the various ways in which citizen science is being used to improve understanding and preservation of cultural heritage in different

contexts. First, an overview of citizen science is provided, then a scoping review of citizen science projects aiming to study or preserve cultural heritage is summarized. Finally, implications of using citizen science to study cultural heritage for school science and interdisciplinary learning is discussed.

Strand 14: Environmental Education and Sustainability
Work-in-progress Roundtable

Role of Basic Sciences in Creating Awareness among School Students & Student-Teachers about Single Use Plastics

Narendra Deshmukh*, Homi Bhabha Centre for Science Education, TIFR, India

ABSTRACT

Plastic pollution, especially the unsustainable use of single-use plastic (SUP) products is a critical issue that impacts human health, environment and biodiversity of the world. In many countries the need for integration of this issue into the educational system for both primary, secondary schools and teacher education has often been overlooked, leading to a major challenge in raising environmental awareness. However, UNESCO is supporting countries to integrate sustainability through Education for Sustainable Development. The "International Year of Basic Sciences for Sustainable Development" recognizes the vital role of basic sciences in promoting environmental science awareness. Considering this challenge, researcher designed activities & conducted two workshops focused on "Solution to Plastic Pollution," for school students (48) and student-teachers (87) on the occasion of World Environment Day2023. This descriptive mixed method study focused on the role of basic sciences in creating awareness and understanding the impact of designed activities. Data was collected by using questionnaire, workshop presentation and interviews asking their opinions on unsustainable consumption of single-use plastic. Results revealed that designed activities were effective in increasing participants' knowledge and awareness about plastic pollution and the majority of them were able to reflect on their consumption of single-use plastic and ways to reduce it.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Roundtable

Development and Validation of an Instrument Investigating Elementary Teachers' Sense of Agency for Science Instruction

Alison Mercier*, University of Wyoming, USA
Anica Miller-Rushing*, University of Maine, USA
Jennifer Haddad Lingle, University of North Carolina at Greensboro, USA

ABSTRACT

This presentation examines the development and validation of an instrument to help fill in the current research gap concerning quantifiably investigating elementary science teachers' sense of agency for science instruction. The ways in which elementary teachers express their agency concerning science instruction is critical to the science learning outcomes of our youth. Elementary science teacher agency is understudied, and the methodological choices used by researchers thus far have underutilized potential research options such as validated

surveys. Therefore, we developed the Survey of Elementary Teachers' Sense of Agency (SETSA). We determined the SETSA to have a strong fit and reliability based on a confirmatory factor analysis, making it an effective new tool for researchers to quantitatively consider the critically important discursive expressions of elementary science teachers' sense of agency for science instruction.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Work-in-progress Roundtable

Writing for Identity? Exploring the Motivation of Pre-College Students to Participate in Science Publication.

Sarah Fankhauser*, Oxford College, USA

ABSTRACT

In a typical science class, communication exercises may include a variety of outputs including lab reports, posters, reflective writing, or research proposals. However, a growing number of students are engaging in more complex and professional communication endeavors, including scientific publication. The chance to write a research paper and experience the peer-review and publication processes may provide students the opportunity to integrate several practices from the Next Generation Science Standards, as well as share their research in a more public setting. Although we have some limited understanding in terms of the outcomes that students experience when engaging in peer-review and publication of their science research papers, we have no information or data regarding why students want to participate in these processes. As such, the purpose of this study is to investigate the motivations of pre-college students to pursue peer-review and publication of their scientific research papers. Using the theory of science identity to analyze the data, I found that students view publication as a mechanism to grow their scientific skills and be recognized as a scientist. The findings suggest that providing students the opportunity to share their research in more public settings could be a factor in developing their science identity.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Work-in-progress Roundtable

Influence of Summer Research Experiences on High School Students Science Identity

Nidaa Makki*, The University of Akron, USA
Katrina Halasa*, Akron Public Schools, USA
Kristin Koskey*, Drexel University, USA

ABSTRACT

This paper outlines the influence of a summer research experience for high school students on their science identity. Authentic science experiences include opportunities for students to develop research questions, design and conduct investigations, interpret findings and communicate results while participating in a scientific community. Research suggests that these experiences have potential to increase students' motivation and interest for science and engineering. We used Carlone and Johnson's framework (2007) for science identity, which outlines facets of science identity along the constructs of competence, performance, and recognition. Using a mixed methods design, we investigated the influence of an authentic summer research experience that purposefully integrated social emotional learning strategies (SEL). Data collection included pre and post student surveys, exit interviews, and mentor surveys and focus group interviews. Preliminary results from this work in progress indicate positive influences of the intervention on students' competence and performance. Additionally, students highlighted aspects of the program that focused on learning SEL strategies (e.g. teamwork, dealing with difficult situations) as influential to their learning.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Roundtable

Exposing a Hidden Reality, What Middle School Students Said About Their Lived Elementary Science Experiences.

Tryna Knox*, SMU, USA

ABSTRACT

The voices of middle school students were elicited to examine elementary science experiences to expose a hidden reality. A handwritten science autobiography was administered to 52 students at a private school in a suburban southwestern community. Middle school students described and explained elementary science experiences in many interesting and informative ways. There are important implications for this work. Teachers can learn a lot by eliciting student voices and embracing feedback from students. Student benefit by personally reflecting on prior learning experiences and become empowered when they share their voices in science classrooms. Current and future teachers learn more about each student's foundational learning experiences so they can instructionally meet students where they are, regardless of where they come from. School decision-makers can benefit when they have robust measures of academic outcomes that include qualitative information that includes the students' perspective and tells a more complete story. And finally, the research community can benefit from new research that both supports published work and extends the work by introducing results of this phenomenological study of lived elementary science experiences using the science autobiography as a tool for eliciting student voice.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Roundtable

Reading for Science: The Use of Scientific Literary Materials in Primary Schools

Fay Lewis*, University of the West of England, United Kingdom
Jane Carter*, University of the West of England, United Kingdom
Juliet Edmonds, University of the West of England, United Kingdom
Ann Alston, University of the West of England, United Kingdom
Stephanie Sargeant, University of the West of England, United Kingdom

ABSTRACT
Scientific literary materials (SLMs) present science content in genres such as narratives and poems as well as traditional non-fiction genres. SLMs have the potential to engage children and teachers who are non-science enthusiasts or specialists with science content and could address many of the current issues with science education. However, little is known about their use. This paper uses a mixed-method approach to analyse how SLMs are employed as tools for teaching and learning about science and their role within English lessons. Findings demonstrated that whilst SLMs are available in schools these are narrow in range and genre. They are used for factual research and are rarely read for pleasure. They are also not exploited as a pedagogical tool within English lessons. A range of barriers to their effective use were identified. We conclude that if we are to encourage teachers to use SLMs as a technique for engaging a wider audience with science they must be helped to adopt them more widely in the classroom and curriculum. This paper presents a range of recommendations as to how teachers can be supported with a wider range of resources and materials so that they can draw more effectively on SLMs.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies
Roundtable

Using Teaching Debriefs to Explore the Emerging Science Teaching Identity of a Veteran Elementary Teacher

Terrance Burgess*, Michigan State University, USA

ABSTRACT
The Next Generation Science Standards were developed as a tool to engage all students in equitable science learning. Specifically, the standards arguably incorporate equitable instructional practices through its promotion of three-dimensional instruction, where teachers are expected to enact science instruction that engages disciplinary core ideas through scientific and engineering practices and crosscutting concepts. Juxtaposing these expectations to existing scholarship, we know that elementary students in the United States have very limited opportunities to engage in science learning. Thus, we must understand how elementary teachers view themselves as ready to take on this charge, and what supports may be required to foster a science teaching identity. Taken together, this year-long case study focuses on one fifth-grade classroom to gain insight into these issues. Although this classroom uses NGSS-aligned curricula, findings indicate that a veteran teacher begins to develop an agentic science teaching identity by engaging in in-depth teaching debriefs designed to unpack student knowledge while leveraging their interdisciplinary pedagogical expertise. These emerging findings are insightful and offer a significant contribution to the limited research detailing support for in-service elementary science teachers.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Work-in-progress Roundtable

Data-Informed Teaching: An Examination of Faculty Use of Student Data Dashboards for Classroom Instruction

Veronika Rozhenkova*, University of California Irvine, USA

Maryam Eslami, University of California Irvine, USA
Celine Crooks, University of California Irvine, USA
Brian Sato, University of California Irvine, USA

ABSTRACT
Improving undergraduate instruction while also addressing the issues of diversity and inclusion has been a focus of many STEM programs across the U.S. colleges and universities. Student data-informed teaching, which can help faculty adjust their practices based on their students' characteristics, is not a new phenomenon in the context of higher education. Despite an increase in the construction of student data dashboards, little is known about how instructors' sensemaking and decision-making regarding these tools influence their instructional practices. Using the case of one U.S. research-intensive, minority-serving university where such an analytical data dashboard was designed and introduced, we intended to explore the university instructors' perceptions of utilizing student data in developing and teaching their courses. This study aims to identify the avenues that institutions can take to help faculty utilize such tools more effectively in order to ensure equitable participation of all students. This research has direct implications for improving instruction and enhancing students' learning experiences in STEM disciplines and higher education more broadly.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Roundtable

Situational Interest and Perceived Relevance in Physics Learning Modules

Rauno Neito*, University of Tartu, Estonia
Elisa Vilhunen, University of Helsinki, Finland
Jari Lavonen, University of Helsinki, Finland
Kaido Reivelt, University of Tartu, Estonia

ABSTRACT
Promoting student's interest in science is a critical aim of science education. When designing interest-promoting teaching modules, it is important to consider what is relevant to different student groups (e.g. boys and girls) and what kind of activities trigger situational interest. We examined how individual interest, perceived relevance and activities engaged in during lessons predict situational interest of students; if these activities can be distinguished based on interest and whether there is a difference in levels of interest and relevance between boys and girls. We designed two modules about thermodynamics, taught in the form of workshops, that emphasised usefulness of the topics in everyday life. We collected data on situational interest and perceived relevance using the experience sampling method with four measurements in each module. Results indicated only minor differences in relevance in one module and no difference in situational interest between boys and girls in either module. The best predictor of situational interest was perceived relevance and individual interest was a significant predictor in one module. The effects of different activities varied between modules. We discuss the implications and recommendations based on these results.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Roundtable

Interdisciplinary Assessment of Student Thinking About Variability Across Mathematics and Science Classes in Middle School

Fonya Scott*, Middle Tennessee State University, USA
Ryan Jones, Middle Tennessee State University, USA
Lori Klukowski, Middle Tennessee State University, USA

ABSTRACT

Making decisions with data is an essential skill that includes thinking about statistical practices and their context. In science classes, students are asked to analyze data to justify claims and explain phenomena. Next Generation Science Standards include analyzing and working with data at every grade level, but statistics instruction has been primarily the responsibility of mathematics teachers. The consideration of variability in context mirrors the real-world application of data analysis that science and mathematics teachers hope students will gain as they matriculate (Jones et al., 2023). However, the tools for guiding student development of these skills are primarily developed along disciplinary lines, leaving teachers unable to assess students' understanding of variability in context effectively. Assessments must reveal developing knowledge and skills acquired across multiple subjects when focused on interdisciplinary ideas, such as variability. Currently, there is no way for teachers to track student learning for integrated science, technology, engineering, and mathematics (Gao et al., 2020). This work focuses on an assessment for mathematics or science teachers to collect evidence of connections students make between quantitative and qualitative descriptions of variation by prompting students to utilize statistical and scientific ideas.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Work-in-progress Roundtable

Assessing Pedagogical Content Knowledge for Data Fluency for Middle School STEM Teachers

Rasha Elsayed*, WestEd, USA
Nicole Wong*, WestEd, USA
Leticia Perez*, WestEd, USA
Kirsten Daehler*, WestEd, USA
Pai-rou Chen, WestEd, USA
Corynn Del Core, WestEd, USA

ABSTRACT

This paper describes the development of a written assessment for teachers’ pedagogical content knowledge in data fluency. To date, our team has constructed, pilot-tested, and administered this 1-hour pre-assessment to 12 math and science teachers in the context of a professional learning course to support teachers’ data fluency content and pedagogical content knowledge. We describe our development process, key assessment features, and preliminary findings about what the instrument reveals about teachers' knowledge and skills for supporting students' progression toward data fluency. Preliminary analysis indicates that this instrument is useful for eliciting a range of responses along several dimensions of PCK for data fluency. Such dimensions include knowledge of students' understanding related to data use and their common difficulties, knowledge of purposes of using data in math and science learning, knowledge of instructional strategies to support data fluency, and knowledge for planning data-rich lessons.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Work-in-progress Roundtable

Case Study - Training STEM High School Teachers to Integrate Engineering through Gamification

Leslie Brown*, Utah State University, USA
Marissa Tsugawa, Utah State University, USA

ABSTRACT

In response to the Next Generation Science Standards (NGSS) release in 2013, there was a nationwide push for K-12 schools to include engineering concepts in science classrooms. One problem however, is the lack of teacher preparedness and training towards engineering topics as shown by common engineering misconceptions. To solve this issue, we initiated a case-study investigating the changes in preparedness and interest in teaching engineering throughout a professional development workshop for high school science, technology, engineering, and mathematics (STEM) teachers. In this workshop, we will support and prepare high school STEM teachers to teach engineering problem-solving techniques using gamification of learning instructional methods to increase student problem solving skills and motivation to learn. An anticipated outcome of this study is to break down any misconceptions teachers may have about engineering, provide increased support for STEM teachers to integrate engineering, and to improve STEM teachers' ability and preparedness to teach engineering using gamification of learning instructional methods.

Strand 14: Environmental Education and Sustainability
Roundtable

The Woolly Bully: Increasing Students' Science Identities by Tracking the Hemlock Woolly Adelgid

Tara Goodhue*, University of Massachusetts, Lowell, USA

ABSTRACT

This study focuses on high school students engaging in participatory science at an urban vocational high school in the Northeast. Students involved in the study were shown to have significant deficits in the practices of science stemming from a lack of opportunities to engage with the science practices. In order to mitigate this problem, students participated in a local research university's Hemlock Woolly Adelgid participatory science project, where they collected data in the field, analyzed the data, and submitted it to scientists at the university. A mixed-methods design was used to determine the impact of this project on

students' science identities and performance in science. Findings showed that female students experienced large increases in their performance in science as a result of participation, but male students did not change. The difference in performance was attributed to a visit from a female scientist who inspired female students. Two main themes emerged through the analysis of qualitative data: citizen science gives students glimpses into scientists' lives and multi-sensory immersion into authentic science experiences increases identity and attitudes.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Roundtable

Intersectionality of Race and STEM Contents in Two High School Biology Teachers' Classrooms

Bhaskar Upadhyay*, University of Minnesota, USA
Patricia Avery, University of Minnesota, USA

ABSTRACT

In this paper I present the classroom interactions and personal experiences of two high school biology teachers as they engage students in discussions and discourses of race and racism. The biology contents as well as diverse resources were aligned with how race and racism played in understanding contents and the implications of those contents on teaching and learning. Qualitative nature of the study provided spaces to document how and in what ways teachers were invoking race and racism in their teaching. The data collected over two years included classroom observations and interviews. The data analysis showed that life experiences influenced teachers' inclusion of race and racism in teaching; science does not provide utopic answer to racial discrimination but science could be a good vehicle to debunk insidious influence of race and racism on structures of racism.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Work-in-progress Roundtable

In Search of a New Perspective in Exploration of the Persistent P-12 STEM Achievement Gap

Wardell Powell*, Framingham State University, USA
Angela Chapman*, University of Texas Rio Grande Valley, USA

ABSTRACT

It has long been argued that building the STEM education pipeline requires improvement in the instructional quality of all subjects in general and STEM-related subjects in particular at the K-12 level. However, we are still seeing ethnic and racial achievement gaps in STEM education at both the secondary and tertiary levels. Therefore, one cannot help but wonder why some students in the K-12 system, in particular African Americans and Hispanic students, are still lagging in their exposure to high-quality instruction to equip them with the knowledge to enter successfully and complete careers in science, engineering, and technology. Our goal for this work-in-progress roundtable discussion is to start a conversation to better understand how the education system can use the existing body of

knowledge to reform the P-12 STEM education policies and frameworks. The findings from this discussion will inform all stakeholders, including STEM teacher educators and P-12 education systems.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Work-in-progress Roundtable

Student Motivation to Learn and Pursue Careers in Science

Erica Meyers, Kasson- Mantorville Public Schools ISD 204, USA
Bonnie Boyd*, Independent School District 196, USA
Felicia Leammukda, Saint Cloud State University, USA

ABSTRACT

Research has suggested that students start to lose motivation to learn as they advance in their education. Other studies have connected the lack of motivation to learn science to the decreasing number of people entering careers in science. This mixed methods study focuses on student motivation to learn science and how, if at all, student motivation can be increased with the use of classroom motivational strategies. In this study, the use of motivational strategies such as making science content relatable is explored, in hopes of motivating more students to learn science and perhaps pursue a science career. The goal of this study is to recommend a strategy that connects science content to real-world careers as a way to increase motivation to learn science and spark student interest in pursuing careers in science.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Work-in-progress Roundtable

Exploring A Promising Path Forward: Teacher Engagement with "Civic Science Education"

Maggie Demarse*, Michigan State University, USA

ABSTRACT

This proposal addresses the conference theme, "Science Education for the Rest of Us", by contextualizing the purpose of science education through a social studies lens. This study draws attention to the need for socio-scientific issues to be taught in elementary and middle school classrooms and ultimately, find a place in the standard K-12 curriculum. This study investigates how teachers identify, understand, and implement science and social studies instruction relating to Civic Science Education. The goal of this study is to reveal how teachers can leverage civic learning with science to help students grapple with public issues. Understanding how teachers engage with science and social studies is an important step in designing and enacting Civic Science Education. Findings could help practitioners and educational leaders see the ways science and social studies connect to ensure these topics find a place in the standard K-12 curriculum.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Work-in-progress Roundtable

How Do Teachers in Rural Alaska Make Space for Community Cultural Wealth in the Classroom?

Ginger Shultz*, University of Michigan, USA
Jeffrey Spencer, University of Michigan, USA
Archer Harrold, University of Michigan, USA
Safron Milne, University of Michigan, USA
Danielle Maxwell, University of Michigan, USA

ABSTRACT

Culturally responsive teaching and other culturally affirming approaches seek to transform instruction and improve the educational experiences of students from historically underserved communities. These approaches rely on teacher cultural competence for successful implementation, and teacher education programs have sought to support teacher growth in cultural competence. However, culture is location- and context-dependent, and even when teachers receive culture-based professional development, they must make an ongoing effort to develop cultural competence specific to the community where they teach. This study uses narrative inquiry, field notes, and interviews to explore how science teachers in rural Alaska grow as a result of their interactions with their communities and enact classroom lessons that align with students' cultural value sets. We share a narrative account of one teacher's experience when community members brought a bowhead whale lung to his classroom. The narrative captures how the teacher recognizes and affirms students' Community Cultural Wealth in their classroom. These findings illustrate the importance of the relationships formed between teachers and community members in enabling students to learn science in culturally affirming ways.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Roundtable

A Scientific Laboratory-Based Course Aimed at Improving the Scientific Attitudes and Skills of Non-Science Majors

Brian Rempel, University of Alberta, Canada
Sheryl Gares, University of Alberta, Canada
Ellen Watson*, Brandon University, Canada

ABSTRACT

A science laboratory course designed to introduce students registered in non-science majors to scientific skills and attitudes using four-day rotations through biology, chemistry, and physics laboratory experiments was recently introduced as a 3-week block course at a Western Canadian institution. The course objective was to maximize student learning of scientific modes of thinking and doing while minimizing disciplinary content. To evaluate whether the course was achieving this objective, our newly developed [Campus name] Interdisciplinary Scientific Literacy Evaluation (*ISLE) was administered to all students as a pre- and post-test to quantify changes in scientific skills and attitudes. Analysis of numeric

*ISLE scores for study participants (n=172) revealed that post-test scores increased for most participants and the increase was significant ($p=0.00005$). Separate analyses of questions coded for scientific skills or attitudes revealed a significant increase ($p=0.00002$) only for questions aimed at measuring scientific skills, but no significant change in scores on questions aimed at measuring scientific attitudes. These results demonstrate that an interdisciplinary science laboratory course can facilitate the learning of scientific skills by non-science majors using a compressed course format that does not emphasize content. Implications of results for the design of science courses aimed at non-science majors will be discussed.

Strand 5: College Science Teaching and Learning (Grades 13-20) Roundtable

Interactions within Cohorts of STEM Majors from Minoritized Groups: The Potential for Changing STEM Climate

Stacy Olitsky*, Saint Joseph's University, USA

ABSTRACT

Studies have shown effectiveness of mentoring, cohort participation, and research opportunities for retaining students from minoritized groups. However, there is still the critique that such programs can lead to acclimation rather than equity within STEM departments, with students having to adjust to alienating aspects such as isolation and competition. This qualitative study focuses on students in a program for students from minoritized backgrounds in STEM that includes mentoring, research opportunities, and a cohort model. It investigates the possibility for programs to move beyond acclimation to changing the climate to be more inclusive. Results show that the program components facilitated connection with faculty members and peers, and supported students in developing their own goals which countered views of STEM as overly competitive. Students created communal study groups, reframed goals regarding what it meant to be successful, taught their own workshops, and drew on university resources to expand projects that were meaningful to them and had social impact, such as food production and improving public health. Overall, this study suggests the benefit of programs that foster ongoing productive interactions between students and faculty members in which students can expand their roles and have an influence on STEM climate.

Strand 5: College Science Teaching and Learning (Grades 13-20) Work-in-progress Roundtable

Investigating the Role of Representational Competence and Spatial Ability in Learning With Chemical Representations

Sebastian Nickel*, FAU Erlangen-Nürnberg, Germany
Steffen Brockmüller, FAU Erlangen-Nürnberg, Germany
Sebastian Habig, FAU Erlangen-Nürnberg, Germany

ABSTRACT

Representations play a key role in learning and in problem-solving processes in chemistry. In addition to representational competence (Kozma and Russell, 2007), spatial ability has been

shown to be predictive for achievement in this domain. However, there is a notable lack of research into the influence of different factors of spatial ability onto learning with representation-based tasks. The project presented here aims at providing closer insights into this relationship. In a first qualitative study, the think-aloud method will be used to investigate the reasoning strategies and difficulties of students when working with chemical representations. For this purpose, the students (N = 25) work on representation-based coordination chemistry tasks, which are based on specific skills of representational competence. The videos will be transcribed and analyzed using qualitative content analysis. Based on the results of this study and the model for representational competence postulated by Kozma and Russell (2007), an instrument for measuring and distinguishing the skills of representational competence will be constructed an evaluated by using Rasch analysis. The revised version of the instrument will be used to clarify the dimensionality of representational competence as well as its interplay with different factors of spatial ability measured by standardized psychometric scales.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Work-in-progress Roundtable

Implementing and Evaluating Professional Development for Science Faculty that Impacts Student Learning of Science

Peter Cormas*, Pennsylvania Western University, USA
Louise Nicholson*, Pennsylvania Western University, USA
Min Li, Pennsylvania Western University, USA
Elizabeth Steiner, RAND Corporation, USA
Sy Doan, RAND Corporation, USA

ABSTRACT

The first PD framework for higher education science faculty (instructors) that impacts student learning has been proposed based on PD research from K-12 science education. A three-year PD project that is funded by a recently awarded federal grant is using this framework to inform implementation and evaluation. The first goal of the project is to implement and evaluate PD at a primarily undergraduate institution which is minimally selective and has a high percentage of low socioeconomic students. The objectives to fulfill this goal include (a) implement the framework in learning communities which include the entire science faculty (n=20); (b) use analyzed conversations from PD sessions, interviews, instructional logs, and surveys to determine how PD was implemented; and (c) use an experimental study and qualitative approach for evaluation. The second goal is to increase students' learning in undergraduate science courses. The objectives to fulfill this goal include (a) use pre/post assessments and an experimental study to measure the impacts of PD on student learning; (b) use observation instruments to determine whether participation in PD impacts instructors; and (c) use surveys and analyzed conversations from learning community sessions to determine if PD impacted instructors' knowledge, skills, attitudes, and beliefs.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Work-in-progress Roundtable

Assessing Metacognitive Monitoring in Evolution Understanding

Rahmi Aini*, Middle Tennessee State University, USA
M. Elizabeth Barnes, Middle Tennessee State University, USA

ABSTRACT

This study aims to evaluate students' evolution understanding through metacognitive monitoring, which refers to students' confidence and awareness of their own evolutionary knowledge. The study was conducted on a sample of 2622 students enrolled in introductory biology courses across 18 courses in 11 states. The Evolutionary Attitudes and Literacy Survey (EALS) was used to measure students' understanding of evolution before and after watching a 15-minute video lecture. The study identified the effects of methodological issues on metacognitive monitoring assessment and its effect on assessment responses and calculation formats. The results showed that metacognitive monitoring scores resulted in a more normal distribution compared to traditional scoring, enabling the use of more advance statistical tests. In addition, this study also identified three different properties of students' understanding, including accuracy, inaccuracy/alternative conception, and lack of knowledge/unsure conception. Three items in the EALS were found to have over 50% of students holding inaccurate conceptions both before and after learning evolution. This study highlights the importance of assessing metacognitive monitoring to gain a comprehensive understanding of students' knowledge and judgment, which can inform teaching practices and curriculum development.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Work-in-progress Roundtable

STEM Undergraduate Research Students' Self-Efficacy and Their Learning Practices Within a Multi-Institutional Collaborative Research Community

Hyoung Joon Park*, Oregon State University, USA
Jana Bouwma-Gearhart, Oregon State University, USA

ABSTRACT

Notwithstanding the increasing literature on undergraduate research in science, little attempt has been made to explore undergraduates' self-efficacy and understand how they develop such belief in their capacity to conduct research through a multi-institutional collaborative undergraduate research program. We established our research questions as follows: (1) what learning outcomes do undergraduates feel they have obtained from their undergraduate research program?; (2) what features of the collaborative research community in their undergraduate research program contribute to these students' self-efficacy?; and (3) in what ways do its features support these students' learning experiences and, in turn, lead to the confidence in their ability to conduct research? A qualitative research design will be employed to address the research questions for this study. To be specific, we will use the case study as a research method. A multi-institutional research center in the United States will be selected as a case for this study. We will draw upon a combination of experiential learning theory and social cognitive theory in analyzing data and discussing with

findings. Findings from this study will enable us to develop a model that would better fit to account for undergraduate students' practice of learning through science research in a collaborative setting.

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

Professional Development Design and Implementation to Foster Planning for Culturally Responsive Engineering Experiences

Christopher Irwin*, Florida International University, USA
Darryl Dickerson*, Florida International University, USA
Joshua Ellis*, Louisiana State University, USA
Daniel Adeniranye, Florida International University, USA
Bruk Berhane, Florida International University, USA
Andrew Green, Florida International University, USA
Berry Lamy, Florida International University, USA
Nicholas Oehm, Florida International University, USA

ABSTRACT
In this roundtable session, we will share our recent experiences in designing and conducting a multi-week professional development experience designed to develop in-service STEM teachers' identities and efficacies as culturally responsive educators. This program is part of a larger study in which we aim to address the following research questions: 1) In what ways does the presence of engineering offer teachers a safe way to exchange their identities as experts for identities that are more conducive to engaging students' assets and allowing them to co-opt their own learning? 2) How do partnerships with undergraduate engineering majors support in-service teachers' development of a culturally responsive teacher-of-engineering identity? and 3) How does the development of culturally responsive engineering experiences inform in-service teachers educational practices within their disciplines? Based on participant feedback, the program successfully contributed to building relationships and trust toward engaging in honest conversations about (and openly raising questions and problems of practice from within) what it means to be a culturally responsive educator of STEM. We will share specific considerations in initial design that supported these outcomes, and the adjustments we found ourselves making during the actual professional development to respond to the cultures and assets of our teacher participants.

Equity and Ethics Committee
Sponsored Session

Jhumki Basu Scholars Symposium

18-Mar-24, 8:15 AM-9:45 AM

Location: Governor's Square 10

ORGANIZERS
Regina McCurdy, Georgia Southern University, USA
Alexandria Muller, University of California-Santa Barbara, USA

David Steele, Alder Graduate School of Education, USA
Marsha Simon, University of West Georgia, USA

PANELISTS
Sule Aksoy, City University of New York, USA
Roshni Bano, University of Illinois, Chicago, USA
Haider Ali Bhatti, University of California, Berkeley, USA
Henriette Burns, Southern Illinois University Edwardsville, USA
Alia Hamdan, University of Arizona, USA
Mwenda Kudumu, North Carolina State University, USA
Gozde Tosun, Penn State University, USA
Alexandria Muller, University of California, Santa Barbara, USA
Ren Rende, University of Nebraska at Omaha, USA
Jenny Tilsen, University of Minnesota, USA
Hamza Malik, University of Massachusetts, Dartmouth, USA
Teresa Massey, Georgia State University, USA
Khanh Tran, Purdue University, USA
Carol Waters, University of Houston-Clear Lake, USA

ABSTRACT
This session provides an opportunity for the 2023 Basu Scholars to present their original research. In line with the intention of this scholarship program, this presentation offers scholars a space to engage with, network, and receive feedback from peers and senior scholars in the field. The 2024 Basu Scholars are also encouraged to attend this symposium in order to understand what will be expected of them in the 2025 NARST conference. To accommodate all of the scholars (14 of the 2023 Basu Scholars will be presenting) and to encourage generative dialogue, this 90-minute symposium is designed as an interactive poster session.

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set
Models and (Computational) Modeling
18-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 17

Interconnecting Modeling, System Thinking, and Disciplinary Core Ideas Using Computational System Modeling.

Emil Eidin*, University of Wyoming, USA
Jonathan Bowers, Michigan State University, USA

ABSTRACT
Supporting students in applying system thinking (ST) to make sense of scientific phenomena has gained a consensus among science educators. As part of pursuing this goal, using system computational modeling tools has been shown as a promising avenue. However,

when considering an alignment with NGSS and three-dimensional learning, there is a gap in showing how engagement in the modeling practice, applying system thinking as a cross-cutting- concept, and learning gains of disciplinary core ideas interconnect. In this work, we designed research that allowed us to reveal interconnections between modeling, ST, and DCIs learning gains. We developed a four-week unit about the evaporative-cooling phenomenon implemented in 10th-grade chemistry classes. Throughout the unit, students used a system-dynamics computational modeling tool called SageModeler to construct models that explain the phenomenon and its underlying mechanisms. To assess students learning gain, we evaluated a pre-post 3D aligned assessment. We analyzed automatically generated model indicators for ST, such as the ratio between the number of variables and the number of relationships. Our results show an improvement between the pre-and post-assessment and progressing improvement throughout 14 model iterations. This work is novel in the sense it provides compelling evidence for the interplay between modeling, ST, and DCIs.

A Microanalytic Knowledge Analysis of Middle Schoolers' Ideas About Modeling

Eric Kirk*, University of North Carolina at Chapel Hill, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA
Zhen Xu, University of North Carolina at Chapel Hill, USA
Jamie Elsner, University of North Carolina at Chapel Hill, USA
Li Ke, University of Nevada Reno, USA
Laura Zangori, University of Missouri Columbia, USA

ABSTRACT

There is a growing interest in using multiple models to support a holistic understanding of socioscientific issues and modeling as a scientific practice. In this paper we present findings related to middle school students ideas about models and modeling after participating in a socioscientific issues-based modeling curriculum. After participating in this curriculum, students participated in semi-structured focus group style interviews designed to promote reflection on their modeling performances. Using transcripts generated from their data, we performed a thematic analysis to identify patterns in what students thought about modeling. From this analysis we identified a number of ideas related to both the nature and the purpose of models. Next, drawing on a Knowledge in Peices framework, we performed a knowledge analysis to decompose student understandings into smaller "knowledge elements" which when activated give rise to students' ideas about modeling. From this analysis we identified elements related to the form, purpose, and measures of quality of models. We present contrasting cases of two students to provide examples of specific knowledge elements as well as to illustrate how these elements interact and give rise to more complex ideas about modeling.

Metamodeling Knowledge and Engagement in Modeling Practices: The Role of Content Knowledge

Paul Engelschalt*, Humboldt-Universität zu Berlin, Germany
David Fortus, The Weizmann Institute of Science, Israel
Dirk Krüger*, Freie Universität Berlin, Germany
Annette Upmeier zu Belzen, Humboldt-Universität zu Berlin, Germany

ABSTRACT
Modeling is an important scientific practice in which learners often struggle to engage. Metamodeling knowledge (MMK) is assumed to guide modeling practices. However, while recent studies did not find a correlation between MMK and engagement in modeling practices, other studies have shown that modelers' content knowledge about the phenomenon to be modeled is related to their engagement in modeling practices. How MMK is related to engagement in modeling, depending on modelers' content knowledge about the phenomenon to be modeled, remains a research gap.
This study aims to fill this gap. MMK was operationalized through a diagram task. Engagement in modeling practices was operationalized through modeling tasks about two phenomena with different extents of content knowledge available to participants who were 32 pre-service science teachers. One phenomenon was about a person with a reddened face, for which participants reported having used prior content knowledge for modeling. The other involved a clownfish changing its sex, for which participants reported not having used prior content knowledge for modeling.
MMK correlated with engagement in modeling practices for the clownfish, but not for the reddened face modeling task. This might suggest that MMK is especially important when content knowledge about a phenomenon is not available.

Mechanistic Reasoning in Group Drawing: The Case of Collaborative Gestures.

Vanessa De Andrade*, Universidade de Lisboa, Portugal
Yael Shwartz, Weizmann Institute of Science, Israel
Sofia Freire, Universidade de Lisboa, Portugal
Monica Baptista, Universidade de Lisboa, Portugal

ABSTRACT
Despite drawing to learn has received increasing attention in recent years, less attention has been paid to collaborative drawing. In this presentation, using the lens of embodied cognition, we explore some of the functions of collaborative drawing when students engage in mechanistic reasoning. This study presents a pair of middle school students who jointly attempted to make sense of and explain a chemical phenomenon by co-creating a drawing and reasoning through it. Using a fine-grain multimodal analysis, we examine the role of collaborative drawing in enabling collaborative gestures that work to simulate a system and, ultimately, to reach an understanding of how a mechanism behaves. Collaborative drawing has a potential for learning in science, not restricted to the cognitive activity of externalizing thought on paper; instead, collaborative drawing is a way of embodiment that support different embodied actions, such as gestures.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
COVID-19, Viruses, and Vaccines
18-Mar-24, 8:15 AM-9:45 AM
Location: Directors Row E

An Exploratory Study of Students' Prior Experiences and Concepts of Viruses and Vaccines
Madeline Stallard*, NC State University, USA
Gail Jones*, NC State University, USA
Julianna Nieuwsma, NC State University, USA
Kathleen Bordewieck, NC State University, USA

ABSTRACT
The COVID-19 pandemic revealed the public's limited understanding of viruses and vaccines. Despite the importance of this topic, there is a paucity of research on what students know about vaccines and viruses and their prior experiences with these topics. In this exploratory study, elementary, middle, and high school students were surveyed and interviewed about their knowledge and prior experiences related to vaccines and viruses. Eighty-four participants completed the 40-question Vaccines and Viruses Survey. Thirty-three randomly selected participants participated in a 20-minute interview. Results revealed students' beliefs, misconceptions, and concepts of viruses and vaccines, as well as how previous experiences affected these perspectives. Implications of this study for vaccine and virus instruction and curricula are discussed.

Teaching During the COVID Pandemic: K-12 Science Teachers Tell Their Stories
Lauren Harper*, Horizon Research, Inc., USA
Peggy Trygstad*, Horizon Research, Inc., USA
Anna Bruce, Horizon Research, Inc., USA
Patrick Smith, Horizon Research, Inc., USA

ABSTRACT
During the COVID pandemic, K–12 teachers did their best to provide students with accurate and timely scientific information about COVID within a range of challenging, frightening, and often contentious contexts. Using data collected from interviews with 40 science teachers (10 elementary, 10 middle, 20 high school), we highlight the range of events, activities, practices, and feelings that were part of teachers' daily lives for the past three years. In contrast to the widely circulating facts and figures about the impacts of the pandemic, the vignettes serve to humanize this moment in time by sharing teachers' unique stories in their own words.

The Impacts of the COVID Pandemic on Science Teachers and their Teaching
Peggy Trygstad*, Horizon Research, Inc., USA
Laura Craven, Horizon Research, Inc., USA
Patrick Smith*, Horizon Research, Inc., USA

ABSTRACT
The COVID pandemic has had a significant impact on education, with teachers doing their best to provide high-quality educational experiences while navigating challenges with online instruction, high student absenteeism, limited instructional time, and demanding health and safety policies/procedures. Although all teachers were impacted by the pandemic, science teachers perhaps felt the consequences even more acutely as they shouldered the extra burden of providing students with accurate, up-to-date scientific information about COVID within a climate of distrust, misinformation, and fear. Using data collected in summer 2022 from a national survey of K–12 science teachers, we examine the impacts of COVID on science teachers and their teaching.

Exploring the State of Creativity in an Online Physics Learning Environment During the Covid-19 Pandemic

Fredyrose Ivan Pinar*, De La Salle University, Philippines

ABSTRACT
This study delved into the cultivation of creativity among senior high school physics students in an online learning setup during the Covid-19 pandemic. Through the administration of a survey to 300 Grade 12 health-allied students, the research assessed various facets of creativity, including students' perceptions and the influence of technology-integrated activities. Employing expert consensus and statistical analyses such as Exploratory Factor Analysis (EFA), the study verified the survey's reliability and validity.
The findings highlighted a positive response from students regarding instructors' encouragement of "small c" creativity ($M=4.62$, $SD=.54$) from a 5-point Likert scale, emphasizing a student-centered approach to online physics instruction. Furthermore, a moderate correlation ($r = .43$) emerged between instructor-specific fostering of creativity and students' perception of creativity, affirming the impact of teaching practices on nurturing creativity. Notably, students invested substantial time in collaborative and open-ended tasks, indicating a transformative role of technology in fostering self-directed learning.
Future research avenues encompass exploring barriers to creativity, evaluating students' creative outputs, gauging the impact of creativity and technology integration on academic performance, and investigating the influence of school culture.

Motivating Science Learning When Shifting from Face-to-Face to Distance Learning: Comparing Teachers' and Students' Perspectives

Shira Passentin*, Weizmann Institute of Science, Israel
David Fortus, Weizmann Institute of Science, Israel

ABSTRACT
During COVID-19, science instruction in Israel switched from face-to-face (F2F) to distance learning (DL), without teacher preparation or curriculum changes. Instruction in Junior High School (JHS) continued in DL format until the end of the school year and again in the following school year (2021).
In order to support student learning of science, both in F2F instruction and in DL, it is important to motivate them, foster their desire to learn science, and encourage them to take

part in learning activities. However, science teachers' motivational practices in F2F instruction may not work as well in DL, which can offer opportunities to discover novel ways to inspire students. We studied JHS science teachers known for motivating students in F2F instruction. Drawing on interviews, we examined how their motivational practices changed during the transition to DL, considering both teachers' and students' perspectives of these changes.

Our findings can help teachers and designers of online and hybrid instructional environments learn which aspects of science instruction are not yet supported by existing environments and consider how to address them.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

SC-Organized Paper Set

Inquiry-based Science Teaching

18-Mar-24, 8:15 AM-9:45 AM

Location: Plaza Court 1

The Science Education Research Trends in Indonesian Secondary Schools: A Systematic Review and Bibliometrics Study

M Muchson*, Mallinson Institute for Science Education, Western Michigan University, USA
William Cobern, Mallinson Institute for Science Education, Western Michigan University, USA
Muhammad Saefi, Universitas Islam Maulana Malik Ibrahim Malang, Indonesia

ABSTRACT

Indonesian researchers have published a substantial number of research articles on science education. However, there is no overarching sense of the science education research landscape in Indonesia. The purpose of this study was to provide such an overarching sense with respect to science education research focused on Indonesian secondary schools between 2000 and 2020. Systematic review and bibliometrics methods were used to analyze 287 papers retrieved from Scopus. The study found that the publications have drastically increased since 2017, with only a few of them published in leading science education journals. International collaborations among Indonesian science educators have included many countries, such as Malaysia, Japan, South Korea, the United Kingdom, Australia, Thailand, and Canada. The most common research topics are critical thinking skills, problem-based learning, cooperative learning, HOTS, learning tools, blended learning, creative thinking skills, project-based learning, misconceptions, and lesson study, mostly researched through quantitative rather than qualitative methods. These findings are important for Indonesian science educators to assess their progress and identify areas for improvement to have a greater impact on the community. In the international context, these findings provide critical knowledge for global academics as they initiate and build international networks and collaborations to advance science education globally.

Leveraging Classroom Community to Encourage a Collective Enterprise of Building Science Ideas

Jessica Alzen*, University of Colorado Boulder, USA
Kelsey Edwards*, Northwestern University, USA
Jason Buell, Northwestern University, USA
Chris Griesemer, University of California Davis, USA
Cynthia Passmore, University of California Davis, USA
William Penuel, University of Colorado Boulder, USA
Brian Reiser, Northwestern University, USA

ABSTRACT
Science education reform encourages collaborative classrooms in which students' lived experiences and backgrounds are an important factor in the ways they think about science ideas. However, individual student motivation for group participation varies due to past experiences and comfort among peers. Thus, teachers must establish environments in which students feel safe sharing out of their personal experiences and are motivated to contribute to class discussions. Prior research indicates that when teachers facilitate classroom conversation with a focus on reaching consensus about agreed upon ideas, students engage on a collective enterprise to develop science knowledge. However, there is little work identifying how teachers can create environments in which students are motivated to participate in these ways. This presentation investigates the pivotal role community-oriented norms and classroom practices play in fostering effective student participation in collective knowledge building. We delve into a classroom episode in which the teacher employs consensus-motivated discussion facilitation alongside community-oriented norms and consider their combined influence on cultivating an environment for collective sensemaking of scientific ideas. This study expands prior theory regarding consensus-motivated discussion, highlights the significance of social commitments in promoting meaningful science education, and provides insights into practical ways teachers can enact reforms in tangible ways.

Enhancing High-School Student's Scientific Competency in Evaluating and Designing Scientific Inquiry Through Peer-Reviewed Guided Inquiry

Yu-Jan Tseng*, Centre for General Education, National Sun Yat-sen University, Taiwan
Huann-shyang Lin, Centre for General Education, National Sun Yat-sen University, Taiwan

ABSTRACT
This study aimed to compare students' performance of the scientific competency in evaluating and designing scientific inquiry after they were engaged in different types of guided inquiry teaching intervention. A total of 81 11th-grade students engaged in this quasi-experiment study. Both three groups of students participated in 10-week inquiry-based teaching intervention after the pre-test of the scientific competencies assessment. Considering the teaching intervention, students in experimental group 1 (EG1) participated in peer-reviewed guided inquiry, students in experimental group 2 (EG2) participated in reading-integrated guided inquiry, and students in the comparison group (CG) participated in guided inquiry. The analysis of covariance (ANCOVA) results indicated that both EGs significantly outperformed the CG in the post-test. Additionally, only the EG1 students

performed significantly higher on the post-test for identifying control variables than the performance of CG students. The findings suggested that students' scientific competency in evaluating and designing scientific inquiry can be promoted through guided inquiry. Furthermore, students' ability to identify control variables in experimental design can be enhanced by peer review of experiments.

Instructional Approaches in AP and Introductory High School Science Courses & Their Relations to PCK

Robin Bulleri*, North Carolina State University, USA
Soonhye Park, North Carolina State University, USA

ABSTRACT

This study examined instructional variations between an AP and an introductory science course taught by the same teacher and how pedagogical content knowledge (PCK) is related to the instructional variations. This exploratory qualitative study collected data including interviews, observations, and lesson plans from two high school science teachers who taught both AP and introductory courses in the same school. Data were analyzed through the constant comparative methods, deductive analysis using a priori codes, and enumerative approach. Results highlight that instructional differences were the result of each teacher's approach to teaching rather than the level of the course. Furthermore, each teacher's orientations to teaching science informed their instructional variations and enactment of PCK more than the level of the course.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Educator Development and STEM Teaching
18-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Court 6

Developing Educator Identity in Engineering: A Pilot Case Study with Graduate Teaching Assistants (GTA)

Qingna Jin*, Cape Breton University, Canada
Gokce Akcayir*, University of Alberta, Canada
Kristian Basaraba*, University of Alberta, Canada
Duncan Buchanan*, University of Alberta, Canada
Marnie Jamieson*, University of Alberta, Canada
Mijung Kim*, University of Alberta, Canada
Janelle McFeetors, University of Alberta, Canada
Kerry Rose*, University of Alberta, Canada

ABSTRACT

Graduate teaching assistants (GTAs) are among the most significant contributors to higher education; thus, enhancing and supporting their pedagogical knowledge and competencies is crucial. To meet this need, a program was developed to train GTAs in the Faculty of

Engineering at a Canadian university. This case study aims to explore the perspectives of GTAs in terms of their overall experiences, learnings, and challenges during their participation in the program. The findings revealed that the GTAs highly appreciated the training program, primarily due to their limited familiarity with the provided pedagogical content. Furthermore, the GTAs emphasized the significance of tailored pedagogical content that aligns with their specific roles and responsibilities, along with opportunities to put their learning into practice.

STEM Faculty Professional Development: Measuring the impact on College Student STEM Course Grades

Lynn Tashiro, Sacramento State, USA
Mary McCarthy Hintz*, Sacramento State, USA
Sabrina Solanki, Univeristy of California Irvine, USA
Judith Kusnick, Sacramento State, USA
De-Laine Cyrenne*, Sacramento State, USA

ABSTRACT

The quality of STEM instruction in higher education has long been a matter of concern, leading to increased emphasis on professional development (PD) in teaching and learning. Yet little research has been done to investigate the impact of PD on STEM student outcomes. This study aims to fill the gap in research literature and demonstrate a model that can be used to estimate the impact of STEM faculty PD on student outcomes by addressing two questions:
1. Can STEM faculty development have a measurable impact on student course grades?
2. What characteristics of STEM faculty PD contribute to improvement in student course performance?
A multiple methods study was conducted at a large public university using both a difference-in-difference (DID) analysis to compare student course grades before and after faculty PD programs across three groups, and a qualitative analysis of faculty reflections. The no-treatment group did not participate in any PD. A second group participated in a general university PD. A third group participated in a STEM specific PD. Only the STEM PD group showed significant improvement in student grades compared to the no-treatment group. Faculty reflections were used to investigate differences between the PD programs to help explain this difference.

Physics Professors' Pedagogical Decisions and Adoption of Research-Based Instructional Strategies

Christy Metzger*, University of Delaware, USA

ABSTRACT

Despite the large body of research on physics education that calls for student-centered and active pedagogical design with research-based instructional strategies, there is little cohesion and adoption at the university level. There is a disconnect between research and teaching in undergraduate introductory physics courses. This study examines the teaching practices of physics professors to better understand how professors describe their own teaching and the choices they make about their instructional strategies. The data was collected utilizing a qualitative methodology of semi-structured interviews with 18 professors from 10 different universities and colleges. Results show that a) most professors lecture and many describe it as their main teaching style, b) few professors describe their pedagogical choices as research-based, and c) few professors have been formally trained in teaching. Recommendations are made for researchers to consider partnerships with professors to encourage the long-term adoption of research-based instructional strategies.

Investigating Faculty Engagement in Developing Citizen/community Science Course Projects Utilizing a Socioscientific Issues-Based Approach

Stephen Witzig*, University of Massachusetts Dartmouth, USA
Hamza Malik, University of Massachusetts Dartmouth, USA
Rachel Stronach, University of Massachusetts Dartmouth, USA
Kathryn Kavanagh, University of Massachusetts Dartmouth, USA
Robert Gegear, University of Massachusetts Dartmouth, USA

ABSTRACT

Science faculty at universities are required to teach college-level courses in their discipline despite their lack of pedagogical training to do so. This a problem because research has shown that half of the students initially majoring in STEM fields leave for non-STEM majors by their second year in college. Our research addresses this critical need for faculty support by studying a program that provides targeted research-based faculty development utilizing a socioscientific issues (SSI) based approach to engage students as scientists through citizen/community science. This qualitative research was guided using case study methodology, included seventeen faculty from eight institutions, and investigated the research question: In what ways do faculty, and future faculty, incorporate citizen science into their instruction using a socioscientific issues based instructional model? Through our investigation, we have established the following three assertions: (1) Faculty attended to the SSI framework recommendations by presenting the issue first and connecting to students' lives; (2) Faculty grappled with how best to incorporate citizen/community science projects into their courses to address their issue; and, (3) The workshop created a sense of community that the faculty valued. We hope this study sparks discussion and look forward to receiving feedback on the findings.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set
Learning in Science Museums
18-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Court 4

Promoting Inclusive Visits using Virtual Reality to a Museum of Natural History for Autistic Families

Darby Drageset, University of Florida, USA
Yu-Chia (Irene) Kao, University of Florida, USA

Nigel Newbutt, University of Florida, USA
Kent Crippen*, University of Florida, USA

ABSTRACT
Given the affordances and alignment between virtual reality (VR) technologies and some autistic individuals, coupled with the lack of research utilizing VR as a pre-visit material to encourage accessibility and inclusion in natural history museums, we sought to understand the potential role VR could play in supporting autistic families at an inclusive, sensory-friendly event. These events are exclusive to autistic visitors and provide a range of sensory-related accommodations. As pre-visit material for five different family groups, we deployed a VR tour that provided a realistic representation of the museum and used a multiple case study methodology framed by the Contextual Model of Learning to investigate the user experience and impact on a physical visit. Cross-family comparisons indicate several positive features across several domains, including clarity of text; absence of overwhelming crowds; ease of navigation; and the ability to move closer to exhibits to see detail. The tour lessened anxiety and created a sense of predictability. These findings support a greater understanding of the personal context of autistic visitors and their families, which can lead to future application of VR technology in creating inclusive museum experiences that go beyond physical access to the space.

Creating Science Learning Spaces: Lessons Learned from a Museum Science Program
Jacqueline Horgan*, Teachers College Columbia University, USA
Felicia Mensah, Teachers College Columbia University, USA

ABSTRACT
School science has been criticized for its irrelevant, content-heavy, and boring characteristics. Alternatively, out-of-school science learning has been shown to enhance students' science motivation, creativity, self-efficacy, and interest. As a result, students who experience science in out-of-school contexts are more likely to develop personal identifications with science than those who only engage in science at school. Using a Cultural Learning Pathways framework, this study explored how 6th grade students of color, who graduated from an eight-year long museum science program described their science learning experiences in a museum compared to learning experiences at school. Findings showed students felt the museum program created "a homespace", offered greater access to exciting and authentic science learning, and provided more opportunity for familial connections than their school. This research demonstrates the need to approach science education from a life-long, life-wide, and life-deep perspective. The museum science program can offer a framework for science educators to apply to their science teaching practices and build a sense of belonging to students of color for out-of-school science.

Students' Conceptual Knowledge, but Not Their Interest, Help Make Use of a Socio-Scientific Museum Exhibition
Melanie Keller*, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Sarah Kellberg, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Jeffrey Nordine, University of Iowa, USA

Doris Lewalter, LMU Ludwig Maximilians Universität, Germany

ABSTRACT
In this study, we set out to test the effectiveness of an agential exhibition on the energy transition and how students' conceptual energy knowledge and topic interest help them to make use of such an exhibition. Specifically, we investigated the effectiveness with regards to two aspects of energy literacy (critical energy literacy in the form of arguments for and against renewable and conventional energy sources; willingness to act pro-environmentally). We found that overall students profited from the exhibition visit in terms of their critical energy literacy. Specifically, we found that albeit students being still in favor of the energy transition after the visit, they were able to evaluate energy sources in a more differentiated way. This ability to critically evaluate advantages and disadvantages of energy sources went along with an increase in their willingness to act pro-environmentally. Furthermore, we found that conceptual energy knowledge, but not topic interest, acted as a prerequisite to the increase in number of arguments pro and contra renewable conventional energy sources. In the presentation, we will explore what the findings mean for linking formal and informal science education.

A Hopeful Future: Knowledge and Ideological Resources for Learning at an Innovative Museum Exhibit

Lynne Zummo*, University of Utah, USA
Benjamin Janney, University of Utah, USA
Carrie Schultz, University of Utah, USA

ABSTRACT
As trusted public institutions, museums could offer crucial opportunities for climate learning. Yet, there is not empirically-grounded consensus about what works. We investigate visitor learning at an innovative climate exhibit, Hopeful Future (HF), which offers a counternarrative to educational experiences that scare, polarize, and/or exclude learners, developed through iterative design guided by research on message framing. We collected data from 33 participant groups as they interacted with a prototype mock-up of HF while wearing audio recorders. Integrating theories of knowledge and ideology, we investigated learners' use of resources at HF through discourse analysis. We found that learners brought a diverse array of resources to engaging with HF. Knowledge resources tended to be about either the impacts of climate change or potential solutions. Ideological resources often served to locate blame. We found that a playful framing of climate messaging tended to mitigate use of ideological resources around blame placing. We offer implications for educational practice around climate change, for both informal and formal educators, as well as implications for future research.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Approaches to Assessments across STEM Disciplines
18-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Court 2

Research Strategies and Assessments of Online Source Credibility by Pre-Service Chemistry Teachers
Dennis Dietz*, Freie Universität Berlin, Germany
Arne Petter, Freie Universität Berlin, Germany
Claus Bolte, Freie Universität Berlin, Germany

ABSTRACT
Young people are poorly competent in dealing with disinformation on the Internet (e.g., Breakstone et al., 2021). How German pre-service teachers proceed - who will be responsible for teaching the researching of credible information in the future - is currently unclear. In this study, we investigated both the strategies pre-service chemistry teachers use to research on a scientic question as well as the heuristics they apply to assess the credibility of online sources. Adapting the method proposed by Barzilai & Zohar (2012), we videotaped 25 chemistry pre-service teachers conducting open-ended Internet research (including think-aloud) on the question, if smoking e-cigarettes is healthier than conventional combustion cigarettes for people who have difficulies with quitting smoking. To reconstruct the assessment procedures, we conducted retrospective interviews. Our results indicate that while pre-service teachers from this study have an awareness of authors' possible intent to persuade, they rarely use functional techniques – such as those used by professional fact-checkers – to obtain credible information. Our findings demonstrate the need to develop new educational programs for pre-service teachers in the future that focus more on strategies for researching credible information on the Internet.

Reflection on Physics Teaching – a Comparison of a Performance Assessment and a Multiple-Choice Assessment
Anna Weißbach*, University Bremen, Germany
Christoph Kulgemeyer, University Bremen, Germany

ABSTRACT
There is a broad consensus about the importance of reflection on teaching and its benefits to professional development. At the same time, various studies reveal that (pre-service) science teachers' reflection skills are rather low. Accordingly, there is a need to foster the development of reflection skills and therefore a need for resource-efficient diagnosis and feedback that can be implemented through multiple-choice (MC) tasks. Also, it can be assumed that the assessment of complex skills such as reflection requires authentic learning environments. In this study, a performance assessment and a MC assessment providing assessment feedback which differ in the assessment method but cover similar topics related to physics teaching are compared. Data suggests a moderate correlation between the two

assessment methods. The main difference between the assessments is whether noticing is required for the reflection (as implemented in the performance assessment) or recorded separately (MC assessment). The closeness between reflection and noticing can also be observed on the basis of a correlation analysis between the two skills. It is concluded that both assessments are suitable for different occasions depending on whether the focus is on authentic assessment (performance assessment) or on supporting and guiding reflection and providing timely feedback (MC assessment).

Considering Multiple Sources of Validity Evidence to Address Challenges in Developing PCK Multiple-Choice Items

Tobias Lieberei*, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Leroy Großmann, Freie Universität Berlin, Germany
Virginia Welter, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Dirk Krüger, Freie Universität Berlin, Germany
Moritz Krell, IPN - Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT

Multiple-choice instruments for assessing pedagogical content knowledge (PCK) have advantages in terms of test economy and objectivity, but also pose challenges, e.g., in terms of adequately capturing the intended construct. To help clarify these challenges, we report on the development and validation of a new test instrument to assess biology teachers' PCK on scientific reasoning (PCKSR-bio). Among a sample of N=67 master's students, we found a significant correlation between the PCKSR-bio score and the corresponding content knowledge (CK). Additionally, an analysis of N=10 bachelor's students' response processes (collected via interview) revealed that they more often referred to PCK when selecting an attractor and more often referred to intuitive knowledge when selecting a distractor. Furthermore, the PCKSR-bio test was used in a cross-sectional study with N=165 (pre-service) teachers to determine the homogeneity of response patterns and the correlation of the test score with the level of education. Although the participants' responses turned out to be rather heterogenous on the whole, the homogeneity increased with higher educational level. Despite some methodological limitations, which will be discussed in detail to make recommendations for test developers, our results provide support for the assumption of a valid interpretation of the PCKSR-bio test score.

Strand 7: Pre-service Science Teacher Education

SC-Organized Paper Set

Research and Insights on Approaches About Preservice Science Teacher Education Frameworks

18-Mar-24, 8:15 AM-9:45 AM

Location: Plaza Court 3

Establishing Common Ground in Empirical Research on Science Teachers' Lesson Planning: A Scoping Review

Leroy Großmann*, Freie Universität Berlin, Germany

Maren Koberstein-Schwarz, Universität Hildesheim, Germany
Daniel Scholl, Universität Siegen, Germany
Dirk Krüger, Freie Universität Berlin, Germany
Anke Meisert, Universität Hildesheim, Germany

ABSTRACT
Although lesson planning forms a core part of science teachers' professional expertise, there is neither a heuristic model describing which knowledge and skills are necessary and illustrating their interplay in lesson planning processes nor an overview of this emerging field of research consolidating current findings and proposing trajectories for further investigation. To close this gap, we conducted a scoping review of N = 66 empirical studies in science education research investigating science teachers' lesson planning between 1987 and 2022. We find that most studies target the identification of conceptual knowledge (n = 44) rather than investigating science teachers' procedural knowledge (n = 14) in lesson planning processes. Moreover, most studies focus on the creation of mental or written lesson plans (n = 54), and only a few additionally consider the justification of planning decisions (n = 9). An analysis of the bibliographic coupling among the reviewed studies reveals that researchers in the field do not yet relate to a common theoretical ground. Hence, we summarize our findings in a modified version of the Refined Consensus Model of PCK specified for lesson planning, which might facilitate research on science teachers' lesson planning.

Making Beyond the University Classroom: Lessons from Preservice Teachers Participating in a Mobile Making Program

Myunghwan Shin*, California State University, Fresno, USA
Alexandria Hansen*, California State University, Fresno, USA

ABSTRACT
This study explores the impact of a "Mobile Making" program on preservice elementary teachers' understanding and perspectives of maker or STEM education. The program involves a service-learning course in which preservice teachers learn about maker education theories and methodologies in a university setting and then transition to guiding elementary students through making activities in afterschool programs. In particular, the study aims to investigate the learning opportunities and challenges identified by preservice teachers during their participation in the program and how these shape their beliefs, knowledge, and practices regarding maker or STEM education. The research is informed by prior studies on maker education in teacher preparation programs and mobile makerspaces. Grounded theory is employed to analyze qualitative data collected from field notes, lesson plans, and digital portfolios of 45 preservice elementary teachers. The study identifies three key themes: 1) becoming STEM teachers through empowering children with making, 2) making or STEM for all, and 3) overcoming STEM anxiety. This study contributes to the development of a tailored model for integrating maker or STEM education into preservice teacher training programs.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Connections Between Teachers' Epistemic Beliefs and Instruction
18-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 12

Science Teachers' Beliefs About Teaching and Learning Science Contents and Scientific Practices
Verena Petermann*, Justus Liebig University Giessen, Germany
Andreas Vorholzer, Technical University of Munich, Germany
Claudia von Aufschnaiter, Justus Liebig University Giessen, Germany

ABSTRACT
Fostering students' understanding of science contents and scientific practices are both important goals of science education. However, it seems that in classroom practice, science content knowledge is typically addressed explicitly, but scientific practice knowledge is not. It can be assumed that this difference in classroom practice is at least in part related to science teachers' beliefs about teaching and learning science contents and scientific practices. This study investigated and contrasted teachers' beliefs regarding these two goals. Data was collected from N = 170 teachers with an online questionnaire. After modeling the data and assessing the quality of measurement via Rasch analysis techniques, t-tests were used to compare beliefs. The results reveal that science teachers' beliefs can vary considerably between both goals. For instance, teachers believe that fostering students' understanding of scientific practices requires primarily doing science while being explicitly informed about the rules and strategies for engaging appropriately in scientific practices (e.g., control of variables strategy) is of lesser relevance. In contrast, teachers believe that for the learning of science content, explicit information about corresponding knowledge is of higher relevance. The presen_tation will provide an overview of the observed differences. Implications for research and teacher education will be discussed.

Shifting Epistemic Authority in Science Education: Understanding Teacher Transitions in Knowledge Generation Environments
Jale Ercan-Dursun*, The University of Alabama, USA
Jee Suh, The University of Alabama, USA
Ercin Sahin, The University of Iowa, USA
Brian Hand, The University of Iowa, USA
Gavin Fulmer, The University of Iowa, USA

ABSTRACT
In this research, an adapted concern-based framework was employed to comprehend the intricate interplay among teacher commitments, learning processes, and concerns regarding change. Our aim was to understand how these factors come into play as teachers transition their orientations towards knowledge-generative environments and the shift of epistemic authority. A case study was conducted involving eleven elementary teachers engaged in a

professional development program centered on a knowledge generation approach called Science Writing Heuristics. Interviews, vignettes, and open-ended reflections were gathered from teachers during the initial two-year period of the PD initiative. We initially categorized teachers based on their orientations towards generative learning: 1) High Generative Learning Orientation, 2) Low Generative Learning Orientation, and 3) Modest Generative Learning Orientation. Subsequently, a comprehensive analysis was carried out into teachers' commitments, learning processes, and concerns. It was observed that teachers with a low generative learning orientation exhibited distinct learning patterns when compared to those with high or modest orientations. This group demonstrated a limited grasp of epistemic tools, displayed diminished personal motivation towards the PD experience, and expressed personal concerns related to the practical implementation of generative pedagogy. Finally, we discussed the implications of our model for teacher change and professional development.

Exploring Relationships Among Science Teachers' Pedagogical Content Knowledge, Epistemic Orientations, and Implementation of Model-Based Teaching

Grace Carroll*, North Carolina State University, USA
Soonhye Park, North Carolina State University, USA
Matt Reynolds, North Carolina State University, USA
Amanda Hall, North Carolina State University, USA
Laura Chalfant, North Carolina State University, USA
Scott Ragan, North Carolina State University, USA
Jason Painter, North Carolina State University, USA

ABSTRACT

This study explores the relationship between pedagogical content knowledge (PCK) and epistemological orientations (EOs) in the context of implementing Modeling Instruction (MI), filling research gaps on teacher-level constructs impacting science reform adoption. Insights for improving professional development and mentoring to enhance knowledge and foster reform-congruent beliefs are provided. A mixed methods design analyzed PCK and EOs' influence on two teachers' instructional decisions during MI implementation. Findings reveal impacts of PCK integration levels and epistemic alignment on MI implementation and teachers' reflective processes. PCK alone did not explain teachers' in-the-moment decisions and EOs were vital for interpreting these cases, suggesting future work should clarify conceptualizations of PCK to determine the quality PCK necessary for reform-congruent science teaching.

Tackling the Epistemic and Dialogic Aspects of Interdisciplinary Argumentation Among Science Teachers

David Perl-Nussbaum*, Weizmann Institute of Science, Israel
Baruch Schwarz, The Hebrew University of Jerusalem, Israel
Edit Yerushalmi, Weizmann Institute of Science, Israel

ABSTRACT
This study examines the conditions for fostering interdisciplinary dialogic argumentation in science classrooms in order to enhance both epistemic practices and discourse deliberativeness among learners. It focuses on out-of-field physics teachers with a background in biology who participate in a professional development program together with in-field physics teachers. We describe our PD approach and task design guidelines that aim to encourage each group to draw on their disciplinary epistemic practices and engage in mutual knowledge construction in physics. We examine the relations between group composition (homogeneous vs. heterogeneous) and the type of discourse developed among teachers (the dialogic), as well as the epistemic practices they use in the course of their scientific reasoning. Our preliminary findings suggest that the careful design of dialogic argumentation activities in an interdisciplinary group has the potential to develop rich epistemic practices among science learners.

Strand 8: In-service Science Teacher Education
Related Paper Set
Curriculum-Based Professional Learning: Multiple Approaches to Working with Teachers of Diverse Student Groups
18-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 14

Professional Learning Design to Enhance Elementary Teacher's Pedagogical Design Capacity to Adapt Curriculum Materials
Katahdin (Kate) Cook Whitt*, Maine Mathematics and Science Alliance, USA
Lisa Kenyon, Maine Mathematics and Science Alliance, USA

ABSTRACT
This proposal explores one strategy to deepen teachers' engagement with curriculum materials and adapt them to local contexts through curriculum-based professional learning focused on both scientific sensemaking and phenomenon adaptation. Key design elements of two distinct professional learning approaches are explored through design-based research. Across two design cycles, our professional learning interventions were crafted to elevate elementary educators' adeptness in nurturing scientific sensemaking that centers phenomena related to their place, interests, and identities. Approach 1 emphasizes enhancing teachers' familiarity with curriculum materials and scientific sensemaking while encouraging asynchronous exploration of local contexts. Approach 2 integrates curriculum-embedded resources to deepen engagement with materials and sensemaking practices while focusing synchronous time on phenomena adaptation and place. Our investigation indicates that the second design iteration, distinguished by its focus on phenomena adaptation abetted by curriculum-embedded supports in the materials, yielded notable advancements in teacher resources for both scientific sensemaking and phenomena adaptation. This study's contributions lie in its innovative approach to professional learning, which fosters pedagogical shifts in science teaching and equitable instruction, and its

potential to shape future curriculum development and teacher professional development initiatives for elementary educators.

Curriculum-Based Professional Development for Integrating Science and Language with Multilingual Learners

Alison Haas, New York University, USA
Okhee Lee*, New York University, USA
Abigail Schwenger, New York University, USA
Scott Grapin, University of Miami, USA

ABSTRACT
While there has been significant progress in the development of NGSS-designed curriculum materials, development of PD programs is just beginning. The demand for full interventions consisting of curriculum materials and PD programs has become even more urgent due to the rapidly growing diversity of the student population, including multilingual learners (MLs). Currently, we are carrying out a multi-year project to implement and test a curriculum-based PD program integrating science and language with MLs. Grounded in the perspective of symmetry – that teacher professional learning experiences should be symmetrical to the learning experiences we organize for students (Mehta & Fine, 2019), our conceptual framework for the PD program consists of design principles. During the first year, we offered a two-day in-person PD workshop before each of the four units. We present findings in terms of (a) teacher feedback and preparedness at the end of each PD workshop and across the four PD workshops and (b) revisions to PD workshops over the year. Our PD program could serve as a prototype for PD programs to facilitate uptake of NGSS-designed curriculum materials with MLs. Moreover, the full intervention could serve as a prototype for scale-up of an intervention with MLs.

Sustained Professional Learning to Promote Teaching Elementary Science in Large Urban Schools

Cory Susanne Miller*, Michigan State University, USA
Joseph Krajcik*, Michigan State University, USA

ABSTRACT
Access to high quality curricular materials is important for the implementation of elementary science aligned to the Framework for K- 12 Science Education and NGSS (Short & Hirsh, 2020). Open education resource materials address this challenge, but with them comes other challenges that need to be addressed. There are incoherences around science reform implementation at each level of the elementary school system, making science teaching and learning difficult in classrooms (Cherbow et al., 2020). Teachers need sustained curriculum-based professional learning (PL) to implement curricula that require a deep pedagogical shift (Hubbard et al., 2006). Professional learning experiences should focus on generalizable pedagogical components of reform-based materials and engaging teachers through modeling teaching with the curricular materials (Author, 2014). Engagement in a community of practice is important for developing individual identity and fostering personal growth (Wenger, 1998). This paper explores how one large urban district built capacity as they adopt

and scale new open source, NGSS aligned curriculum materials. We discuss the importance of building partnerships (Coburn et al., 2021) with district leaders, science coordinators and teacher leaders to promote scaling and adoption of the materials. We will discuss the successes that move our work forward and hindrances we've encountered.

Professional Learning to Support Teachers Customization of Middle School Science Curriculum to Support Equitable Sensemaking

Katherine McNeill*, Boston College, USA
Renee Affolter, Boston College, USA
Benjamin Lowell, New York University, USA
Austin Moore, Boston College, USA
Maria Moreno Vera, Boston College, USA
Samuel Lee, Boston College, USA

ABSTRACT

Curriculum can provide a vision and strategies for what is possible in science instruction. However, teachers need to be responsive to the students within their classrooms to create more just learning environments. As such, teachers need to customize curriculum materials for their particular localized classroom setting. Consequently, in this study we used a case study approach to investigate how teachers' instructional beliefs and their views of implementing curriculum changed during a curriculum based professional learning (CBPL) experience focused on customizing existing curriculum materials. Specifically, we worked with 52 teachers during a professional learning sequence consisting of three components: a two-day in-person workshop, a two-hour virtual follow up, and enactment of one customization.We analyzed multiple data sources including surveys, video of the workshops, artifacts, teachers' lesson customizations, and their reflections. Our findings suggest that for the majority of teachers their relationship with the curriculum changed. Engagement in the CBPL influenced the teachers shifting their view of curriculum use away from teaching as a script to one in which teachers had greater autonomy. Furthermore, this process helped teachers rethink and expand what counted as a customization including smaller changes centered on the needs of the students.

Strand 10: Curriculum and Assessment & Colorado Science Education Research

Related Paper Set

Building from Strengths and Attending to Context: Supporting Rural Science Teachers' Learning

18-Mar-24, 8:15 AM-9:45 AM

Location: Directors Row H

Lessons Learned from Designing 5D Professional Learning for Rural Science Teachers

Abraham Lo*, BSCS Science Learning, USA
Annie Allen, University of Colorado, Boulder, USA
Kevin Cherbow, BSCS Science Learning, USA

Sara Cooper, University of Colorado, Boulder, USA
Loraine Glidewell, University of Colorado, Boulder, USA
Cari Herrmann Abell, BSCS Science Learning, USA
Keelin O'Connor, University of Colorado, Boulder, USA
William Penuel, University of Colorado, Boulder, USA

ABSTRACT
This research study investigated the extent to which an online course supported rural teachers in developing assessments that provide students with the opportunity to use the 3Ds to explain phenomena or solving engineering problems that engage student interest and support science-linked identity development. The course is an adaptation of a 2-day, in-person workshop and was designed to enhance rural teachers' access to high quality professional learning. Efforts were made to build community among rural teachers who often lack peers with whom to collaborate. This study documents the specific challenges rural teachers face in designing tasks to elicit students' understanding of the 3Ds in ways that connect to their interests and identities and how we used what we learned to iterate upon our design to create a more coherent and effective experience for our teachers.

Opportunities and Challenges in Designing Phenomena-Based Tasks Rooted in Student-Identified Community Issues

Keelin O'Connor*, University of Colorado, Boulder, USA
William Penuel, University of Colorado, Boulder, USA
Kerri Wingert, University of Colorado, Boulder, USA

ABSTRACT
This paper focuses on a 5D course aim that phenomena should be relevant and important to students and their communities. It explores community concerns that students from three design study classrooms named as important to them, phenomena their teachers selected for assessments, and the process teachers used to select them. To analyze issues important to students and their communities, we conducted a thematic coding of student responses to two questions on a survey administered by their teachers: "What are two issues that members of your community are concerned about?" and "Why are these issues important to your community?" To identify phenomena teachers chose, we did a content analysis of post-course assessment tasks that teachers designed to align with the 5D vision. We analyzed a submission form teachers completed, and conducted semi-structured interviews to analyze how they chose phenomena for their assessments, as well as their experiences designing phenomenon-based tasks using student interests. While no teachers developed a phenomenon specifically rooted in students' responses, each drew on student interests in different ways, and indicated challenges they faced in designing tasks to meet the 5D vision through interviews and the submission form. Our findings directly inform revisions to the experimental 5D course.

A Comparative Case Analysis of Rural Teachers' Experience with 5D Professional Learning

Loraine Glidewell*, University of Colorado Boulder, USA
Kerri Wingert, University of Colorado Boulder, USA
Annie Allen, University of Colorado Boulder, USA
Jennifer Jacobs, University of Colorado Boulder, USA

ABSTRACT

This paper presents a comparative case analysis of three rural teachers who participated in an online professional learning course focused on 5D assessment. Taking the stance that rural teachers have both shared needs and differences, we asked: How do teachers' contexts and experiences help explain variation in changes to their vision for science teaching and instructional practice? The data source for case selection was a survey given to examine their vision for science teaching and instructional practice. Three teachers were chosen at the upper, middle, and bottom quartiles in terms of gains. We used census information, course observations and artifacts, exit tickets, and interviews to construct case profiles. Findings suggest that 1) the course was more beneficial for teachers entering with extensive NGSS experience, 2) virtual learning presented technological difficulties, 3) the workload in the course was especially overwhelming for those who teach multiple grade levels and content areas, 4) teachers valued centering students' interest and identities, and 5) teachers appreciated collaborating with other rural teachers. Our hope is that these findings will help inform future professional learning designs for rural teachers, and also be applicable for supporting any teachers interested in implementing a 5D vision in their classroom.

Investigating the Impact of a 5D Professional Learning Course on Rural Teachers' Assessment Practices

Cari Herrmann Abell*, BSCS Science Learning, USA
Abraham Lo*, BSCS Science Learning, USA
Kevin Cherbow, BSCS Science Learning, USA
Sara Cooper, University of Colorado Boulder, USA
April Gardner, BSCS Science Learning, USA
Keelin O'Connor, University of Colorado Boulder, USA

ABSTRACT

This paper explores the efficacy of a revised three-month, online professional learning course designed to support rural teachers in designing five-dimensional (5D) assessment tasks that explicitly attend to students' interest and practice-linked identity development. We conducted a randomized control study with 55 rural teachers from 13 states. Before and after experiencing the course, teachers submitted an assessment they developed or modified to make it aligned with the 5D vision. The assessments were scored using a rubric we developed to measure the extent to which the teacher-designed assessments aligned with the 5D vision. Overall, treatment teachers significantly outperformed the comparison teachers on their post-test assessments. Treatment teachers shifted away from using phenomena as contexts for demonstrating 3D understanding toward phenomena that drive multidimensional sensemaking. However, greater support is needed to ensure that teachers are making explicit what is puzzling about the phenomena and developing opportunities for students to use the dimensions at the elemental level. These findings show the promise of

the online professional learning course in supporting rural teachers to shift their assessment practices toward a 5D vision, but also highlight the challenges teachers face even after experiencing in-depth professional learning.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set
Moving Towards Equity and Racial Justice
18-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Court 5

Colorado Science Education Research

Moving Genetics Education Beyond Mendel Can Reduce Racial Prejudice
Brian Donovan, BSCS Science Learning, USA
Monica Weindling*, BSCS Science Learning, USA
Dennis Lee, BSCS Science Learning, USA
Awais Syed, BSCS Science Learning, USA

ABSTRACT
Genetics education affects how students explain racial inequality. For example, when students learn about race during Mendelian genetics, they believe more strongly that racial inequality is genetically determined. In contrast, studies tentatively suggest that if students learn about the complexity of genomics and race it can reduce this same belief. In this proposal, we investigate for the first time how different types of genetics instruction affect three different conceptions of race that influence how students make sense of racial inequality: (a) genetic essentialism, (b) racial colorblindness, and (c) social constructionism. Through a pre-registered cluster-randomized trial (N = 1063 biology students in N = 6 states), we demonstrate that the ideal instructional sequence to reduce essentialism, avoid colorblindness, and increase constructionism is to introduce students to the models of Mendelian genetics and then move beyond these models and highlight their limitations using insights from genomics that refute racist assumptions.

Developing Measures of Scientific Self-Perceptions and Interest in Elementary Students Historically Underrepresented in STEM
Kristin Gagnier*, AnLar, USA
Steven Holochwost, Lehman College, the City University of New York, USA
Melissa Ceren, The Graduate Center, the City University of New York, USA
Kelly Fisher, AnLar, USA

ABSTRACT
Racial and socioeconomic disparities in STEM achievement emerge early and widen over time. Research has shown that students' self-perceptions and interest drive achievement in STEM, thus leading to efforts to increase underrepresented students' interest and efficacy in science. However, a lack of reliable and valid measures to assess elementary students' scientific self-perceptions and interests has hindered our capacity to determine the

effectiveness of such efforts. We developed such measures and established their properties in a sample of third-grade students traditionally underrepresented in STEM careers (98% of our sample identified as Black or Latino). This paper presents initial evidence for the reliability and validity of these measures and reveals their multi-dimensional nature. Such measures contribute to both theory and practice. They can be used by researchers to uncover the nature of young students' scientific self-perceptions and by practitioners and evaluators to identify effective programs.

An Analysis of Socially Relevant, Justice-Oriented Approaches in Highly-Rated NGSS-Designed Science Curriculum Materials

Monica Sircar*, Stanford University, USA

ABSTRACT

This study explores the extent to which highly-rated curriculum materials designed for the Next Generation Science Standards (NGSS) reflect socially relevant, justice-oriented approaches in their framing of phenomena or problems. I analyzed the content of unit overviews from science curricula that have earned high ratings from an independent NGSS review process. Half of the units framed phenomena or problems around pressing societal issues. Units focused on physical science content were less than half as likely to center on societal issues compared to units that included either life science or earth and space science content, especially when units focused on physical science without integrating content objectives from these other domains. Overall, units reflected little attention to power or injustice in the framing of phenomena and problems. These findings suggest that while socially relevant, justice-oriented approaches are compatible with NGSS design, taking up these approaches requires pushing beyond what current standards demand and what current curriculum evaluation tools value. These results highlight an ongoing need for NGSS-designed materials that also reflect socially relevant, justice-oriented approaches, as well as a need for evaluation tools that incorporate centering societal issues and justice in the definition of high-quality science curricula.

Pre-Service Teachers' Misconceptions of Culturally Relevant Pedagogy Assessed Via Q-Methodology

Ebonee Maxey*, University of Georgia, USA
Mary Atwater, University of Georgia, USA

ABSTRACT

Culturally relevant pedagogy helps students connect better with topics taught in the classroom, it does this by impacting the curriculum a teacher uses and directly challenges the educator to alter the basics towards a version that is better understood by the students (Ladson-Billings et al. 1995). As classrooms become more diverse and the teacher demographics don't reflect this change in diversity it becomes more essential for preservice teachers to understand culturally relevant practices and mindsets. Using Q methodology can reduce researcher bias and help diminish some of the bias that exists with the use of basic surveying and self-reporting tools (Watts et al. 2012). Q methodology can do this because it is an assessment-based tool that uses factor analysis and group perceptions through the

sorting of statements into a specific grid format, from this Q-sort one can isolate themes and subgroups within a larger group (Watts et al. 2012). This pilot study offers a set of procedures and an assessment tool that can better gauge what misconceptions preservice teachers might have of culturally relevant pedagogy. If these misconceptions are directly addressed and altered, preservice teachers might be more willing to implement culturally relevant pedagogy within their classrooms.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Cultivating Science Identities: Recognizing Family Contributions in Nurturing Curiosity and Navigating Transitions
18-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 11

Building on Curiosity to Support Youth Science Identity Development Through Caregiver-Child Conversations

Nicole Villa*, Florida International University, USA
Remy Dou, Florida International University, USA
Heidi Cian, MMSA, USA
Amy Padolf, Fairchild Tropical Botanic Garden, USA
Kavita Mitapalli, MN Associates, Inc., USA

ABSTRACT
We present findings from a pilot study exploring the relationship between caregiver-child engagement in Curious Talk and Science Talk, and their associations with science identity. Students who contributed (N = 113) attended secondary schools in predominantly Latine school districts and were participants in a year-long STEM program spanning formal and informal settings and involving student-directed explorations of space related agriculture. Structural equation modeling with bootstrapping revealed that Curious Talk had an indirect association with science identity that is fully mediated by Science Talk. This relationship held even when controlling for family interest in science. Findings underscore the role of family conversations in shaping science identity and highlight "curiosity" as a construct worth renewed attention, particularly in relation to our understanding of identity development. We present initial insights that may be relevant to the design of science education programming that aims to foster children's science identities, including for children who identify with Latine communities or who may perceive their families as not having an interest in science. While we hedge our findings within the limitations of our sample, we believe our they are likely to prompt renewed conversations around the study of curiosity within the NARST community.

Transition Into Upper Secondary Science and Mathematics as a Young Muslim Woman With Immigrant Background

Emilie Gertz*, Department of Science Education, Denmark

ABSTRACT

To increase participations in science, technology, engineering & mathematics (STEM) independent of social background, ethnicity, and gender, several research calls have been made to strengthen our understanding of how different identities intersect in forming an identity within STEM.

This study supports these calls by using an intersectionality lens to explore Erina's transition in upper secondary school science and mathematics as a young Muslim woman with non-western immigrant background. It offers insights into some of the ways multiple identities: gender identity, science identity, math identity, religious identity, ethnic identity, and social-class identity can intersect in the transition.

Findings show that Erina's religious identity, ethnic identity and social class positioned her as an outsider in the new educational context due to a switch in social and cultural school context. This challenged her in performing in accordance with the gendered expectations of being hardworking and diligent. Additionally, her ethic identity at times blocked her being recognized performing at the same level at her peers. By being a rick-taker and abandoning the idea of fitting into these gendered expectations, she found herself able to form a sense of identity within mathematics and chemistry, while physics offered far too narrow possibilities to be recognized within.

Fostering STEM Interest and Identity in the "STEM in our Lives" Project

Cory Buxton*, Oregon State University, USA
Diana Crespo Camacho, Oregon State University, USA
Barbara Ettenauer, Oregon State University, USA
Karla Hale, Western Oregon University, USA

ABSTRACT

Science educators have a responsibility to help all students make sense of societal challenges and opportunities that affect their daily lives, their futures, their communities, and society broadly. To support this goal, the "STEM in our Lives" Project engages science teachers, who work with students in grades 4th to 12th, in developing and adapting tools and practices that foster all students' language development, cultural and community connections, and knowledge building through science. This study analyzes a set of student work samples from an activity called "My family STEM story" to consider how students from communities across Oregon conceptualized the roles that STEM plays in their lives, their families, and their communities. We argue that such integrated framings for STEM in our lives can support goals around broadening participation in STEM pathways, while also supporting students in developing and maintaining positive STEM interests and identities. We analyzed 51 student work samples to consider the following two research questions: (1) How did students describe the current roles that STEM plays in their own lives and the lives of their families?, and (2) How did students describe aspirational roles that STEM can play in their own lives and the lives of their families?

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Reflecting on Tensions in Centering Community Knowledge and Desettling Onto-Epistemic Hierarchies
18-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 15

'Whose Knowledge Counts?': Reflections on Participatory Design Principles to Enable Transformative Learning in Science Education.

Deborah Dutta*, Institute of Rural Management Anand, India
Geetanjali Date, Maharashtra State Faculty Development Academy, India
Sugat Dabholkar*, Rutgers University, USA

ABSTRACT
Developing a transformative agenda in education requires an explicit structural critique of deficit-oriented narratives, along with alternate visions and newer methodologies to create critical, meaningful learning environments. This paper shares a global perspective and highlights the intersections between power, knowledge and social change by illustrating three cases that used a participatory co-design approach to 'desettle' assumptions of epistemological directionality. Following Bang and Vossoughi's (2016) exhortations to go beyond co-design principles to engage in collaborative practices of knowledge co-creation along with the 'researched', the studies seek to highlight the tensions and possibilities that emerged in the process. Based on intersubjective insights from data, the paper seeks to problematize the notions of expertise and articulate trajectories that allow for prioritizing perspectives and ideas from situated knowledge. The work attempts to contribute to the discussion around educational approaches to social change-making by drawing attention to the emergent relational and structural dimensions of participatory co-design initiatives.

Kilo: A Model of Community Centered Integrated Science and Data Science Learning.

Colby Tofel-Grehl*, Utah State University, USA
Tyler Hansen, Utah State University, USA

ABSTRACT
Data science and science practices overlap in several ways that can inform best engagement with the Next Generation Science Standards (NGSS) for meaning making within science classrooms. As the NGSS articulates, grappling with data through data collection, interpretation, and analysis furthers youth engagement with and understanding of science phenomena (NGSS Lead States, 2013). Of equal importance to engaging with and understanding scientific phenomena, finding localized meaning with the science learned is essential to youth's growing sense of connection with science. This paper explores the ways that a community centered integrated data science and science project focused on local ecological concerns of an invasive species fostered youth science interest, learning, and agency.

Exploring the Potential of Indigenous Science Knowledge for a Culturally Enriched Elementary Climate Education Curriculum

Mohd Syafiq Aiman Mat Noor*, University of Leeds, United Kingdom
Roslinawati Roslan, Universiti Brunei Darussalam, Brunei Darussalam
Hardimah Said, Universiti Brunei Darussalam, Brunei Darussalam
Marlizayati Johari, Universiti Brunei Darussalam, Brunei Darussalam

ABSTRACT

Research has shown that current elementary education provision is inadequate in cultivating students' understanding and awareness of the climate crisis. While indigenous science knowledge systems are increasingly being recognized as rich and valuable, they are still often ignored. Drawing on research carried out with indigenous Iban communities in Brunei Darussalam, this paper explores the potential of indigenous science knowledge for a culturally enriched elementary climate education curriculum. The research involved two stages. In the first stage, interviews and site visits with key stakeholders were conducted to identify, understand, and map the indigenous science knowledge embedded within the community, as well as to comprehend the community's viewpoints on the climate crisis. In the second stage, the research focused on developing a climate education curriculum, grounded in a community-based approach and the integration of local indigenous science knowledge. This stage involved the collaborative efforts of teachers, parents, and curriculum specialists in the form of four study group sessions and an expert group meeting. The two-fold process outlined in this research could have important implications for science education, as it highlights the value of recognizing and valuing indigenous science knowledge in creating a more culturally relevant and effective climate education.

Navigating Intersections of Westernized STEM Education and Indigenous Perspectives in Oceania

Tobias Irish*, University of Hawaii at Hilo, USA
Joseph Genz*, University of Hawaii at Hilo, USA
Monique Storie*, University of Guam, USA

ABSTRACT

This study addresses issues of underrepresentation of Native Hawaiians and Pacific Islanders in STEM by sharing stories of how students from Oceania navigate the complex intersection of Westernized STEM education and Indigenous perspectives and how this impacts their self-efficacy and the development of their personal STEM identity. Culturally responsive, ethnographic interviews were conducted with 50 students from 11 different campuses across Oceania. The initial findings reveal that for students from Oceania, the desire for a career in STEM manifests from a deep sense of commitment to their family, community, the environment, and their culture. For many, the desire is to use what they have learned in their STEM program to in some way contribute to the betterment of their community and proliferation of their culture. However, a lack of cultural representation in STEM programs and limited curricular relevancy can make it difficult to navigate these experiences in ways that lead to their desired outcomes. In our presentation, we will share what we have learned

about how students navigate these issues psychologically, academically, and culturally. In doing so, we hope to provide insight into how to best support students from Oceania in their journey toward a personally meaningful career in STEM.

Strand 11: Cultural, Social, and Gender Issues
Symposium
The Arts' Roles in Centering Equity, Justice, and Liberation Vis-A-Vis Science Knowledge and Identity Construction
18-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 16

The Arts' Roles in Centering Equity, Justice, and Liberation Vis-A-Vis Science Knowledge and Identity Construction

Maria Varelas*, University of Illinois Chicago, USA
Dionne Champion*, University of Florida, USA
Folashade Solomon*, TERC, USA
Mindy Chappell*, Portland State University, USA
Maria Kolovou*, University of Miami, USA
Nathan Mitchell*, University of Wisconsin-Madison, USA
Rebecca Kotler, University of Illinois Chicago, USA
Ronan Rock*, University of Illinois Chicago, USA
Ayesha Qazi-Lampert, University of Illinois Chicago, USA
Brezhnev Batres, University of Illinois Chicago, USA

ABSTRACT
As science education research expands to design and study efforts to educate those interested in pursuing science and 'the rest of us,' the intersections of the arts and the sciences become even more important to explore. Arts-based ways of knowing, being, exploring, and communicating center humanizing pedagogies where the composer, performer, or artist creates meaning via various semiotic systems that are a part of the art in which they are engaged. The various modes involved in the arts have different affordances and, thus, together they maximize individual and collective meaning, affect, and agency. Thus, bringing together scholars who are grounded in the practice of science teaching at various contexts and have been practicing and studying ways in which the arts contribute to the construction of knowledges and identities in science education settings seems to be a timely matter. The symposium presenters will share their thinking on how engaging learners with practices of the arts (visual, theatre/drama, dance) creates affordances for thinking about science and science education ideas, making sense of them, situating them in sociocultural and sociopolitical contexts, and crafting identities as people engaged in science who negotiate multiple positions in the world, in school, and in science.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set
Post-Secondary Nature of Science
18-Mar-24, 8:15 AM-9:45 AM
Location: Directors Row J

Explicit Incorporation of the Nature of Science in an Undergraduate Science Content Course: Action Research
Esther Kataate Namakula*, Indiana University, USA
Valarie Akerson, Indiana University, USA

ABSTRACT
This study addresses the integration of explicit Nature of Science (NOS) instruction within an undergraduate scientific inquiry environmental course, to enhance preservice teachers' understanding of NOS concepts and scientific inquiry skills. Drawing on action research principles and guided by key theoretical frameworks, the study employs a mixed-method approach to explore the effects of NOS incorporation into the instruction. Pre- and post-questionnaires, assignment reflections, and inquiry projects were employed for data collection. Quantitative analysis of pre-questionnaire responses revealed shifts from "Towards Adequate" to "Adequate" perceptions, indicating improved NOS understanding. Qualitative insights from post-questionnaire responses showcased heightened awareness of NOS tenets, particularly empirical evidence and observation while revealing areas for focused instruction like scientific method and hypotheses. Inquiry projects illuminated students' recognition of NOS tenets in scientific articles and highlighted strengths in certain aspects while identifying areas needing clarity. This study emphasizes the significance of targeted instruction in areas such as the scientific method and science content. NARST members engaged in science education, curriculum design, and research will find this study valuable for enhancing science teacher preparation and advancing pedagogical strategies, fostering improved NOS understanding and scientific literacy among students.

Understanding the Nature of Engineering: Insights from Faculty and Practicing Engineers via open-ended VNOE-B Questionnaire
Erdogan Kaya*, George Mason University, USA
Ezgi Yesilyurt*, Weber State University, USA
Hasan Deniz*, University of Nevada, Las Vegas, USA

ABSTRACT
This study aims to explore the views of engineering faculty, engineering education faculty, and practicing engineers on the nature of engineering (NOE) by employing the validated and reliable Views of Nature of Engineering – Version B (VNOE-B) instrument. While emerging NOE scholarship in pre-college science education has begun to focus on teachers' and students' perspectives of NOE, there remains a significant gap in research examining the NOE views of engineering experts. In our investigation, we sought to identify and understand the NOE views of 12 participants including engineering education researchers, practicing

engineers, and engineering faculty representing a diverse array of engineering disciplines. The study utilized a combination of an open-ended VNOE-B questionnaire and follow-up interviews to gather data. The results revealed that participants held nuanced and sophisticated views of engineering, aligned with NOE descriptions found in the literature, K-12 Science Framework, and Next Generation Science Standards. We also discuss the implications of our findings and propose directions for further investigation in the field of fledgling pre-college NOE scholarship.

Strand 14: Environmental Education and Sustainability
Related Paper Set
Considerations for Doing Climate Change Education Work Across Different Contexts, Spaces, and Settings
18-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Court 7

Developing School-Wide Climate Justice Curriculum in a Progressive Context: Affordances of a Social-Ecological Lens

Kathryn Hayes*, CSU East Bay, USA
Emily Harris, BSCS, USA
Eric Nolan, CSU East Bay, USA
Peter Hiester, Cesar Chavez Middle School, USA
Karina Garbesi, CSU East Bay, USA

ABSTRACT
In order to address the wickedly complex issue of climate change, climate education needs to become multi-disciplinary, supporting students to build on their science knowledge as they engage in cross-disciplinary skill-building and justice-focused actions. This study reports on how one middle school built such a cross-curricular approach to climate education through a co-design process involving ten teachers across disciplines, educational researchers, and university faculty, resulting in an average of 62 hours of climate education per student. Using ecological theory (Capra, 2007), we analyzed recordings of planning meetings and interviews over one year to explore how whole school climate justice education emerged. Findings suggest that different opportunities, pressures, and feedback loops prompted the group to make adaptations. For example, to address the challenge of preparing teachers across departments to teach coordinated lessons, the group used department meetings to prepare colleagues and offered flexibility about when to teach lessons. Key resources the group drew on to problem solve included individual teacher's motivation, diversity of subject matter expertise, interdependence and relationships among participants, and niche roles. This study highlights both the successful adaptations and ongoing struggles to create a school-wide multi-disciplinary climate justice curriculum in a progressive area of the United States.

Professional Learning in, for, and with Ethics of Care to Foster Just Climate Change Teaching

Deb Morrison*, University of Washington, USA
Amal Ibourk*, Florida State University, USA

ABSTRACT

This paper presents a research-practice partnership (RPP) model for developing a climate change curriculum grounded around ecological justice and centered on collective care, hope, and love for the environment. This study shares the iterative process that the RPP went through to meet the intersecting goals of providing practical professional learning for curriculum adaptation around climate change while also establishing a caring community to address educators' tensions in teaching this topic in conservative contexts. At all times during the professional activities, we grounded the RPP and curriculum design work around collective care, hope, and love for the environment and the communities the teachers' students live in. Pressure from climate-denial groups is influencing curriculum in many states, causing doubt to be cast on climate science, effective solutions to the climate crisis, and the roles of everyday people in taking climate action; thus, it is critical that examples of climate learning that foster support networks for educators in conservative contexts are developed and shared.

Co-Transformation of Schoolyard Landscapes and Curriculum: A Pilot Study of Emergent Climate Change Teaching Practices

Kathryn Lanouette*, William & Mary, USA
Meredeth Dash, Alliance for the Chesapeake Bay, USA

ABSTRACT

Climate change requires shifts in not only how we teach but also imagining and building thriving, just and sustainable communities and futures (Morales-Doyle, 2022). In this paper, inspired by a learning ecosystem framework (Hecht & Crowley, 2020), we share efforts underway that entail concurrent shifts in the schoolyard socio-ecological system outdoors and elementary science teaching practices indoors, in ways that elevate both historical and contemporary climate injustices while also imaging and enacting more ethical futures (Learning in Places, 2020). Through a multi-year research practice partnership with a public elementary school in a Mid-Atlantic city, there have been deliberate schoolyard transformations to shift from mowed grass monoculture to reforestation efforts that bolster urban forest tree succession and canopies. In this pilot study, we analyze our recent collaborations with two Third grade classrooms and their homeroom teachers. Data sources include student generated artifacts, collaboratively constructed data displays, and researcher planning and field notes. We provide examples of how simultaneous socio-ecological transformations of the school's schoolyard to counter increasing stormwater runoff and heat island impacts are making possible shifts in science teaching and learning practices.

Using Co-Design to Infrastructure Climate Justice Education Across a State-level Teacher Education Network

Phil Bell*, University of Washington, USA
Kelsie Fowler*, University of Washington, USA
Deb Morrison*, University of Washington, USA
Nancy Price*, University of Washington, USA

ABSTRACT

The unfolding climate and environmental crises of today demand that teachers be better prepared to disrupt whiteness, anthropocentrism, and extractive logics in human-nature relations, and in their place seed a transdisciplinary, multi- onto-epistemic and just social and multispecies response. To address this reality, we started a networked improvement community (NIC) of faculty and instructors from 12 different teacher education programs across Washington State to learn about climate justice education and engage in the transformation of teacher education. Fourth generation cultural historical activity theory (CHAT) guides the network's efforts as it engages in dialogue, relationship building, and material/intellectual/social designing and infrastructuring across significant scale. In this study we aim to understand how artifacts collaboratively constructed by the NIC mobilized epistemological, ideological, and political frames. Our analysis of network artifacts (1) identified varied substantive, pedagogical, and critical and political clarity frames and (2) used inductive and iterative coding to note variation in how these dimension was represented. The findings provide examples of different critical and political frames and elements of justice activated through the work. Additionally, this research offers a conceptual framework to guide state-level NICs working to integrate climate and environmental justice into teacher education.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set
Socioscientific Issues in Secondary Science Curriculum
18-Mar-24, 8:15 AM-9:45 AM
Location: Directors Row I

Designing and Evaluating a Teaching Module on Socio-scientific Topics within the 10th-grade Ecology Unit

Mustafa CAKIR*, Marmara University, Turkey
Funda Karaer, Ministry of National Education, Turkey

ABSTRACT

Socio-scientific topics inherently possess characteristics that can lead to diverse individual perspectives, encompassing dilemmas with moral, religious, social, and cultural implications. An instructional module, grounded in a constructivist approach, focusing on the Ecology Unit within the 10th-grade Biology curriculum, contextualized through socio-scientific topics was developed and the aim of this study is to examine the effects of this module on students' academic achievement, attitudes, scientific thinking skills, and decision-making abilities. This study employs a pre-test, post-test control group experimental design. The sample included 140 participants attending a state school. Data was collected using the academic achievement test, which comprised 21 questions and scales measuring attitudes towards socio-scientific topics, scientific thinking, and decision-making skills. Data collection instruments were administered as pre-and post-tests to both experimental and control groups, who had similar achievements in prior science readiness exams. The study was conducted over a 24-week, with a 12-week instruction period. The data was analyzed with a mixed-design analysis of variance. Results for the academic achievement test, scientific thinking skills, and decision-making skills scales revealed statistically significant differences in favor of the experimental group over the control group. There were significant differences in the critical thinking skills sub-dimension and attitudes toward socio-scientific topics.

Teaching Argumentation with Energy-related Socio-scientific Issues: The World Café Approach

Shiang-Yao Liu*, National Taiwan Normal University, Taiwan
Meng-Chin Lee, National Taiwan Normal University, Taiwan

ABSTRACT

Since the term socio-scientific issue (SSI) has appeared in Taiwan's new science curriculum guidelines, this study aims to incorporate an energy-related SSI instructional unit into the Natural Science Inquiry and Practices course and test the plausibility of the World Café approach in science classrooms. Argumentation performance, as one of the course's learning objectives, is the focus of the assessment. A three-week teaching unit was provided to four classes of 10th-grade students by the same teacher. The World Café activities, including group work for formulating discussion topics, three rounds of conversation, and whole-class sharing, provided opportunities for students to practice communication skills and make decisions on issues of their interest. This study followed the mixed methods research design, obtaining quantitative data on students' energy knowledge and scoring the changes in argumentation performance and qualitative data through open-ended questionnaires and group conversation recordings. Results indicated that levels of improvement in students' argumentation performance varied among different classes. Energy knowledge did not correlate with argumentation performance due to the broad content of the questions. However, students' engagement in learning about energy knowledge, the quality of discussion topics, and the atmosphere of peer conversations might affect their learning outcomes, which demands further investigation.

Perspectives for Science Curriculum-Making in the Anthropocene

Xavier Fazio*, Brock University, Canada
Todd Campbell*, University of Connecticut, USA

ABSTRACT

This theoretical paper presentation illuminates how science curriculum-making can be reinvigorated to address urgent local and global socioscientific issues (SSI) that centers place as an interconnected part of larger socio-ecological and socio-technical systems. Given how capitalistic extractive practices have pushed the planet beyond its complex life-sustaining

limits, we draw on theoretical perspectives that recognize schools as complex systems, nested within local, regional, and global social-ecological systems whereby science curriculum-making in these systems prompts dialogue regarding knowledge and competencies required to address planetary sustainability, as well as ontological questions connected to systems, relations, and responsibility. Consequently, schools are important social sites for curriculum practices. Furthermore, teachers, students, administrators, and the school community members are enmeshed with local ecologies that are constituted in the cultural, material, and social arrangements found in or brought to a school and its local community. In our work, we draw on a curriculum commonplaces perspective to investigate curriculum-making practices. Specifically, we use empirical data from two cases of science teachers developing and enacting curriculum and adopt a philosophical-empirical deductive approach illustrative of how to apply complexity theory and systems thinking and associated ontological and epistemological views to practical reasoning of science curriculum-making in schools.

Continental and Diasporic Africa in Science Education (CADASE) Sponsored Session

Unifying Our Community: Implementing Science Education for the Best of Us

18-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 10

Unifying Our Community: Implementing Science Education for the Best of Us

ORGANIZERS
Rona Robinson-Hill, Ball State University, USA
Jonathan Hall, California State University, San Bernardino, USA

PANELISTS
Rona Robinson-Hill, Ball State University, USA
Shari Watkins, American University, USA
Olayinka Mohorn-Mintah, University of Memphis, USA

ABSTRACT
The first part of the 90-minute in person administrative session sponsored by The Continental and Diasporic Africa in Science Education includes a 45-minute plenary presentation with our invited speaker, Dr. Felicia Moore Mensah, which includes time for a question and answer period. Her presentation will be in line with the Continental and Diasporic Africa in Science Education theme, "Unifying Our Community: Implementing Science Education for the Best of Us." The title of Dr. Mensah’s talk is, "How can we take care of others if we do not take care of ourselves?" Our plenary’s keynote address will focus on how our community can work toward individual, collective, and communal well-being. The second half of the administrative session will include a poster session focused on science education endeavors from faculty members and doctoral students from the United States,

the African diaspora, members of the Continental and Diasporic Africa in Science Education, to share their work that focus on our theme.

Equity And Ethics Committee
Sponsored Session
Connecting Science to Every Student's Lived Experiences: Promoting Equitable Science Learning through Diverse Contexts and Perspectives
18-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 11

Connecting Science to Every Student's Lived Experiences: Promoting Equitable Science Learning through Diverse Contexts and Perspectives

ORGANIZERS
Regina McCurdy, Georgia Southern University, USA
Dominick Fantacone, State University of New York - Cortland, USA
Alexandria Muller, University of California - Santa Barbara, USA
Marsha Simon, University of West Georgia, USA

Panelists
Jessica Norberto, Fundação Cecierj, Brazil
Noah Feinstein, University of Wisconsin - Madison, USA
Terrance Burgess, Michigan State University, USA
Scott Cohen, Georgia State University, USA

ABSTRACT
Keeping in mind the NARST Conference 2024 theme, "Science Education for the Rest of Us", the Equity and Ethics Committee's Administrative Symposium session aims to address the interactions between different science contexts and communities including but not limited to informal science learning, citizen science activities, afterschool programs, science museums, K-12 formal science learning, and post-secondary spaces as well. Learning is not isolated to the classroom, but spans across various learning environments that need to support each other (Godec, 2020). This discussion addresses the evident lack of equity, resources, access, and professional development available to certain underrepresented and underserved communities. After-school programs often provide a dedicated space and time for students to engage more deeply in valuable science/STEM learning. Science museums provide high-entertainment hands-on STEM interaction (Falk & Dierking, 2016). However, oftentimes, only particular groups of students can participate, preventing multiple entry points into these science learning opportunities for other students. Issues like transportation, parents' work schedules, family responsibilities, and historic exclusion of non-dominant communities persist, limiting access to this rich network of science education exposure (Archer, 2016). Additionally, diverse and critically significant perspectives, e.g., Indigenous people, deaf & hard of hearing individuals, etc., are often unaddressed or unacknowledged within formal K-12 science education (Medin & Bang, 2014), even though how these

communities interact with the natural world have much to teach westernized science instruction. In this session we explore how different ways of doing and practicing science across various contexts can support relevant lifelong science learning for all.

Strand 1: Science Learning: Development of student understanding
Related Paper Set
Evolution Education for the Rest of Us: Obstacles and Educational Approaches for Teaching and Learning
18-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 17

Preparing the Ground: Introducing Variation and Inheritance in Plants to Kindergarten Children With a Storybook

Isabell Adler*, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Daniela Fiedler, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Ute Harms, IPN - Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
Evolution is the fundamental theory of biology, explaining the origin of biodiversity and the interconnectedness of all life forms through its three core principles: variation, inheritance and selection. Despite ongoing research in science education, evolutionary biology remains a challenging subject, with learners of all ages struggling with misconceptions that hinder their scientific understanding. To cultivate scientific thinking and mitigate the effects of cognitive biases, experts suggest integrating evolution into early science education, thereby facilitating later learning about evolution in school. Studies show that short-term storybook interventions on natural selection have great success with elementary students but fewer impact on kindergarten children (Emmons et al., 2016; Kelemen et al., 2014). Therefore, we designed and evaluated a storybook intervention to foster kindergarten children's ideas about the principles of variation and inheritance in plants. The data collection process included a pre-test, intervention, and post-test, in which a total of 17 children participated. Our findings indicate that the children's mean scores slightly increased from pre- to post-tests, with the exception of the concept of origin of variation, which remained unchanged. The concept that showed the most noticeable improvement after the short-term intervention was the concept of reproduction.

Evolution in Their Everyday Lives: Qualitative Results of a College Biology Expectancy Value Theory Intervention

Lisa Borgerding*, Kent State University, USA
Mark Kershner, Kent State University, USA
Barbara Currey, Kent State University, USA
Adepeju Prince, Kent State University, USA
Kristina Nieves, Kent State University, USA

ABSTRACT
Some biology learners are not motivated to learn evolution because they do not find evolutionary knowledge personally relevant. Expectancy Value Theory (EVT) is a motivational theory that offers promise for improving college biology students' motivation to learn evolution. In this study, an EVT intervention entitled "Finding Evolution in Your Everyday Life" was developed to help college biology learners relate to evolutionary concepts such as variation, mutation, heritability, adaptation, competition, domestication, struggle for existence, and extinction. 139 students from five college biology courses completed 517 EVT posts which served as data to investigate what everyday examples college biology students use to illustrate evolutionary concepts. Qualitative data analysis generated several categories of evolutionarily-relevant examples which differed by prompt and class. Participants most often cited animal examples, especially pets, to illustrate evolutionary concepts. The degree of personal connection varied across prompt, with participants frequently providing personal experiences and including personal photographs.

A Quasi-Experimental Study of the Differential Impacts of Explanation Construction vs. Critique on Evolution Learning
Evan Abreu*, Stony Brook University, USA
Gena Sbeglia, San Diego State University, USA
Ross Nehm, Stony Brook University, USA

ABSTRACT
Providing students multiple opportunities for constructing knowledge is common in science education. However, theoretical arguments have been advanced for shifting focus away from knowledge construction alone and toward the integration of critique. In the field of evolution education, few studies have tested the differential impacts of large-scale interventions comparing explanation critique and construction. In this proposal we employ a large, sufficiently powered sample (n> 500 undergraduates) in a quantitative pre-post test design (with condition replication) to compare equivalent doses of explanation critique/meta-critique and construction in order to determine how they impact (i) evolution knowledge and (ii) evolution explanation accuracy. The interventions (50min) included three conditions: a. explanation construction, b. explanation critique (with 1 replication), and c. meta-critique (critiquing critiques of explanations; 1 replication) for a total of five comparisons. The previously validated CANS and ACORNS instruments were used to measure evolution knowledge and explanation accuracy, respectively, across conditions. Two phenomena were used in the activity: the evolution of human lactase persistence and human skin color. Using HLM, we found that students had large, but equivalent learning gains for all three explanation conditions. We discuss the implications for the role of explanation construction and critique in science education.

Boosting Diagnostic Competence in Evolution Using Chatbots in Classroom Simulations: Insights Into an Explorative Study
Daniela Fiedler*, IPN Kiel, Germany
Daniel Schönle, Furtwangen University, Germany
Christoph Reich, Furtwangen University, Germany

Ute Harms, IPN Kiel, Germany

ABSTRACT
Diagnostic competence is critical for student assessment and essential for biology teachers to support students' learning. Although pre-service teachers develop their diagnostic competence during university studies, this competence often stays tacit in the classroom. Digital technologies like classroom simulations offer new ways to address this challenge. Additionally, including chatbots in simulations that provide instructional support may positively affect students' performance and motivation. Our explorative study investigated how a simulation-chatbot-system for evolution education impacts pre-service biology teachers' diagnostic competence and if and for what purpose the chatbot is used. We applied a classroom simulation for evolution education in which a chatbot was integrated to allow answers to knowledge queries and formative feedback covering pre-service teachers' tactics in the simulation. So far, 41 pre-service biology teachers participated and diagnosed 1283 evolutionary explanations, of which participants correctly diagnosed 36%. Based on the chatbot data, around 30% of the participants used the chatbot for specific knowledge queries, most often concerning descriptions of concepts. Our study provides new insights into innovative digital opportunities to support teachers' professional development and identifies potential factors that might influence learners' performance within a simulation-chatbot-system.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set
Challenges and Tensions in Reframing Science Education in Professional Learning Settings
18-Mar-24, 10:00 AM-11:30 AM
Location: Directors Row E

Reframing "Users" in the Creation of NGSS-aligned Curriculum Materials
McKenna Lane*, University of Illinois Urbana Champaign, USA

ABSTRACT
Museum-based design teams are often interdisciplinary and include a wide range of expertise (Mason, 2015). Given the interdisciplinary and collaborative nature of these teams, members are often both learning from their team members' expertise while also applying that new knowledge to the design of an educational product. This dichotomy is ideal for collaborative design (Dong & Kleinsmann, 2016) but may require additional considerations when designing for K-12 science classrooms. In this study, I asked what tensions do members of a museum-based interdisciplinary design team express related to the challenge of being both a learner and planning for learning while creating learning modules for use in science classrooms? Using thematic analysis, I identified three major themes: seeing other team members as a proxy for students, seeing themselves as a proxy for students, and seeing teachers as mediators. These themes highlight a key tension between the team's ease with imagining the student perspective while designing while raising questions about how to

better support teachers in mediating classroom activities in ways that support the team's goal of providing accurate, authentic, and NGSS-aligned learning experiences.

Challenges and Opportunities in Using Rubrics to Develop Sustainability Focused Curriculum Units

Julia Poel*, Teachers College, Columbia University, USA
Nicholas Leonardi*, University of Illinois Urbana-Champaign, USA
Barbara Hug*, University of Illinois Urbana-Champaign, USA

ABSTRACT

As teachers work to integrate topics of sustainability into their classrooms, they have been challenged to provide students with a holistic, transdisciplinary approach that shifts agency to them by applying science ideas and practices to create a sustainable future. We explore how professional learning participants (teachers and science graduate students) engaged with a rubric structured around the Sustainability Education Framework for Teachers (Warren et al., 2014) while co-designing a science unit. Using a thematic analysis (Braun & Clarke, 2006), we identified themes for how professional learning participants engaged with the framework and rubric to address issues of sustainability in classrooms. Our findings suggest that there are constraints teachers will grapple with when expanding their current content to include sustainability components, and that these conversations can lead to envisioning what science should be taught in schools. Science and sustainability educators should consider how rubrics and professional learning resources more broadly can be formatted and framed in order to align with intended goals and how to structure teams in professional learning settings so participants can draw on others' experiences and ideas to make sense of new information.

How Teachers Make Sense of Multiple Ways of Knowing in Science

Pooja Roy*, University of Illinois Urbana-Champaign, USA
Nicholas Leonardi*, University of Illinois Urbana-Champaign, USA
Barbara Hug*, University of Illinois Urbana-Champaign, USA

ABSTRACT

A Framework for K-12 Science Education (NRC, 2012) recommends making connections to students' interests and experiences in classroom contexts to make learning more equitable. One way to accomplish this is by introducing multiple ways of knowing (Warren et al., 2020) in classrooms to broaden students' perspectives of what science is and who scientists are. To understand how best to support teachers in acknowledging multiple ways of knowing in school classrooms, it is essential to first understand teachers' perceptions of ways of knowing beyond Western science. This study explores how teachers make sense of science when discussing one of the multiple ways of knowing, Traditional Ecological Knowledge (TEK), and its potential role in the classroom. Our findings indicate that professional learning facilitators need to think carefully and critically about how to present multiple ways of knowing to teachers and must consider how to surface perspectives in a safe environment where they can collaborate to make sense of new ideas.

Customizing Curriculum for Greater Relevance: Tensions and Challenges

Yang Zhang*, Northwestern University, USA
Jason Buell, Northwestern University, USA
Brian Reiser, Northwestern University, USA
Kelsey Edwards, Northwestern University, USA

ABSTRACT

NGSS' emphasis on students making sense of phenomena in the real world requires teachers to engage students in questioning and wondering with "the relevance of science to students" (Whittington et al., 2022). When it comes to curriculum customization, teachers often choose making the curriculum more relevant as a focus. However, how relevance is defined and for what purpose remain ambiguous (Stuckey et al., 2013). In this paper, we explore how a group of middle school science teachers approached enhancing an open-source curriculum's relevance in a professional learning community (PLC). Using thematic analysis, we identified the way the teachers grappled with what relevance meant and for what purpose as well as the tensions and challenges emerging from the customization of the curriculum. The findings demonstrate the complexity of how teachers talked about the curriculum's relevance and the tensions from customization for greater relevance.

Secondary Pre-Service Science Teachers' Conceptualization of Responsive Teaching: Perceptions of Constraints

Nessrine Machaka*, University of Illinois at Urbana-Champaign, USA
Christina (Stina) Krist*, University of Illinois at Urbana-Champaign, USA

ABSTRACT

With the demands of current reforms in science education, responsive teaching is an effective way of meeting those demands. However, developing responsive teaching practices is challenging, especially for beginning teachers (Haverly et al., 2020). Researchers have suggested the need for specific professional learning to help teachers learn to be responsive where they could reflect on their thoughts and experiences (Harris, Phillips & Penuel, 2012). Therefore, in this study, we examined what secondary pre-service science teachers (PSSTs) described as influencing their conceptualization of responsive teaching beliefs and practices, focusing on their perceptions of constraints. Four high school PSSTs were interviewed to discuss their tagged moments of teaching in a classroom video clip of responsive teaching. We characterize what they were noticing in teaching with a focus on the constraints that they described as influencing their conceptualization of responsive teaching. We identified several themes for constraints which were categorized to two sub-themes: student-related and teacher-related. With the need for examining how teachers learn to be responsive in specific supportive and professional contexts, these findings will help both teacher educators and researchers better understand the uptake and adoption of responsive teaching practices and support beginning teachers in their journey of learning to be responsive.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set
Technology and Computer Science in Elementary Classrooms
18-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 1

Teachers' Use of ChatGPT to Analyze and Interpret Students' Assessment Responses: A Pilot Study

Hui Jin*, Georgia Southern University, USA
David Owens*, University of Montana, USA
Brian Riordan, Cisco, USA

ABSTRACT
Given the emergence and widespread use of ChatGPT, it is crucial that teachers learn how to work with ChatGPT, which can serve as a reliable and trustworthy collaborator in their day-to-day teaching. Therefore, we conducted a pilot study to investigate how in-serve science teachers used ChatGPT to analyze student data and inform their classroom instruction. Participants were nine science teachers enrolled in an online asynchronous graduate course. Their course work, including individual papers and group papers, were collected. The thematic analysis techniques were used to code these papers and generate themes. The study generated two important results. First, many of the participants' questions, problems, and perspectives suggested that they a lack of a basic understanding of how ChatGPT works. Second, the participants' assessment literacy and prompt engineering skills collectively impacted how they analyze student data and use the analysis results to inform their instruction. Future research is needed to examine how a generic understanding of ChatGPT's function, prompt engineering, and assessment literacy work together affect teachers' use of ChatGPT in day-to-day teaching.

Elementary Teachers' Use of Computational Thinking To Expand Students' Reflection and Epistemic Engagement in Science

Christina Schwarz*, Michigan State University, USA
Wanjoo Ahn, Michigan State University, USA
Aman Yadav, Michigan State University, USA
Zac Opps, Michigan State University, USA

ABSTRACT
While computation and computational thinking plays a critical role in science and society, there have been few opportunities for elementary teachers to easily incorporate computational thinking into their curricula. This research examines how teachers from upper elementary grades used computational thinking practices in their science lessons. Working with a professional learning community to do so, teachers incorporated CT in several ways. Analysis of their video recordings indicates that teachers used the CT to incorporate epistemically or metacognitively rich activities or discourse prompts for their students in

their science lessons. Debugging seemed particularly amenable for teachers to use, enabling students to iteratively revise investigations or application designs. Further, asking students to use CT to metacognitively reflect on their learning or as part of problem-solving approaches to figure out science ideas seemed to fit into lessons and fostered ways to engage students in reflecting and problem solving. If we are serious about engaging learners in our computational society in equitable ways, learning how teachers incorporate CT into their science teaching and what it enables them to do is critical for advancing scientific and computational literacy which will benefit teachers and learners as we move towards the future.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Student Perspectives of Laboratory Experiences
18-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 6

Undergraduate Students' Views of Experimental Physics in Remote and In-Person Laboratories

Luciana Lombardo*, Stony Brook University, USA
Angela Kelly, Stony Brook University, USA

ABSTRACT

Many colleges and universities offer multiple modes of instruction for undergraduate physics laboratories, including traditional, remote hands-on, and studio physics. The present study investigated whether students in online laboratories develop similar attitudes towards physics laboratory learning as their in-person counterparts. An observational quantitative study was conducted during the spring 2023 semester at a large research university in the Northeast United States. Students (N=201) in traditional, online, and studio laboratories were surveyed on 30-item Likert scale E-CLASS survey items that measured attitudes, habits, and views towards common laboratory practices. Students were asked to self-report their performance, grade level, gender, ethnicity, major, average performance, and residential status, as well as whether they were enrolled in algebra- or calculus-based physics. Parametric comparisons of means revealed that there were no differences in students' attitudes, habits, and views in the laboratory for most demographic and academic variables, however, significant differences were found when considering instructional mode and performance. Students in remote laboratories and lower performing students had less positive views towards laboratory learning. Results of this study imply that the laboratory environment is equitable for students of different demographic and academic backgrounds, however, reformed practices may be necessary for online and struggling learners.

Exploring the Competency in Scientific Argumentation of Undergraduate Students in an Asynchronous Online Physics Laboratory

Yuri Piedrahita Uruena*, Purdue University, USA
Carina Rebello*, Toronto Metropolitan University, Canada

N Rebello*, Purdue University, USA

ABSTRACT
Scientific argumentation is identified as a crucial 21st century STEM workforce skill. With the increasing utilization of online learning environments, it becomes imperative to investigate students' argumentation skills in such environments. In this study, the lab reports of first-year students in STEM majors were analyzed in the search for a generation of arguments. Specifically, we explored the quality of scientific argumentation that students in an online physics lab demonstrate in their written lab reports. We also identified the differences between higher- and lower-performing students in the quality of their scientific arguments. Although we expected that higher-performing students would generate better arguments, we did not find this to be a general rule between the different components and types of arguments analyzed in this study. The result suggests that the generation of scientific arguments of quality requires more than mastery of the science concepts.

Investigating Impact of Identities on Perspectives of Failure of Students in Course-Based Undergraduate Research Experiences

Sandhya Krishnan*, University of Colorado - Boulder, USA
Lisa Corwin, University of Colorado - Boulder, USA

ABSTRACT
This project uses a mixed methods approach to investigate how undergraduate students who hold identities minoritized in STEM experience research-based failure in course-based undergraduate research experiences (CUREs). We focus on how identity impacts student views of the instructor supports, coping mechanisms, and epistemic learning that occur through the navigation of these failure experiences, and how these supports, mechanisms and learning mediate changes in certain intrapersonal constructs for these students. We purposefully recruited students from a wide variety of institution types (such as PUIs, community colleges, and research-intensive institutions) and collected data through surveys. Quantitative analysis looked at the relationships amongst intrapersonal constructs such as fear of failure, goal orientation, student-instructor trust, and coping, as key elements of the conceptual model that demonstrates impact the undergraduate learning experience, persistence, and success in STEM. Qualitative data analysis utilized phenomenological variant of ecological systems theory to examine student survey responses. Initial findings demonstrate that close to two-thirds of students who completed the surveys believe that identity impacts their failure experience and that students who hold multiple identities that are minoritized in STEM disciplines feel a cultural burden associated with the notion of failure, which can be mitigated by reframing these identities as resources.

Strand 6: Science Learning in Informal Contexts
Symposium
Participatory Research in Informal Science Education
18-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 14

Participatory Research in Informal Science Education

Neta Shaby*, University of Southampton, United Kingdom
Ran Peleg*, University of Southampton, United Kingdom
Molly Shea*, University of Washington, USA
Meghna Nag Chowdhuri*, University College London, United Kingdom
Louise Archer*, University College London, United Kingdom
Edna Tan*, University of North Carolina at Greensboro, USA
Ti'Era Worsley, University of North Carolina at Greensboro, USA
Virginia Swindell, University of North Carolina at Greensboro, USA
Wisam Sedawi, University of Michigan, USA
Angela Calabrese Barton, University of Michigan, USA

ABSTRACT
Traditionally, research is conducted by university researchers, however, over the years, a movement towards more inclusive research emerged in several research areas, calling for a more equal and equitable approaches, considering the voices of those being researched, recognizing and valuing the expertise/knowledge they have and use it as the basis for research and planning. This type of research encompasses a range of approaches and methods and largely referred to as participatory research (PR). In recent years, PR became more apparent in the educational field in general and in science education in particular. Additionally, there is a growing body of research using PR approaches within informal learning environments. In this symposium we will present various studies done in different informal settings such as science museums, centers and maker space, with diverse co-researchers and a range of methods. We will illustrate the main approaches and methods of the various studies, and focus on the reflection side of PR, from both the expert researchers and the co-researchers. The findings from each study will be a starting point to discuss the questions related to PR and to provide practical tools to others that would like to explore PR.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Approaches to Exploring Preservice Learning and Teaching
18-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 2

Pre-Service Middle School Teachers Lead Discussions in a Simulated classroom: Toward Epistemologically Responsive Science Teaching

Daniel Levin*, University of Maryland, USA
Ethan Carpenter*, University of Maryland, USA
Katerina Gorlenko*, University of Maryland, USA
Tomoka Ogawa*, University of Maryland, USA
J Mesiner*, University of Maryland, USA

ABSTRACT

The turn toward practice-based teacher education (PBTE) has highlighted the value of approximations of practice in pre-service teacher education. In this paper, we report on research on one particular kind of approximation: the use of virtual avatar students in an augmented reality classroom. We explore how pre-service teachers (PSTs) practiced leading discussions in which they facilitated avatar students' construction of explanations for scientific phenomena at the beginning and at the end of a middle school science teaching methods course. Using a taxonomy of types of responsive teaching, we showed that all of the PSTs were able to attend to the substance of students' thinking even in the first approximation, and most PSTs developed greater responsiveness to students' causal mechanistic reasoning by the end of the course. Our findings suggest that a science methods course employing pedagogies of PBTE can support PSTs in developing responsiveness to students' causal mechanistic reasoning. Furthermore, used as it is here, in a methods course just before the student teaching internship, the approximation can provide a bridge between methods courses and student teaching. Teacher educators can communicate with classroom supervisors to provide insight into how to help particular PSTs develop core practices.

Preparing Preservice Science Teachers to Enact Responsive Teaching Using a Video- and Practice-Based Teaching Intervention

Kennedy Chan*, The University of Hong Kong, Hong Kong

ABSTRACT

This paper explores how PSTs learn to enact the core practice of eliciting and working with student thinking in a video- and practice-based teaching intervention designed to enhance their ability to enact responsive teaching. The teaching intervention provided PSTs with a unique opportunity to rehearse responsive teaching moves incrementally in specially designed, tightly constrained approximations of practice called mini-rehearsals. Using a multi grain-sized responsive teaching practice framework, we examined how PSTs' ability to enact the focal core practice changed after the teaching intervention. We also examined how the teaching intervention in general and the mini-rehearsals in particular influenced their learning. Analysis of data from the microteaching videos before and after the teaching intervention revealed that the PSTs improved their ability to enact the focal core practice. However, PSTs had difficulty enacting some of the medium grain-sized responsive teaching moves. All the PSTs found the teaching intervention very or extremely useful in preparing them to learn and enact the core practice. The PSTs reported two unique benefits of the mini-rehearsals in supporting their learning. Implications for how to better support PSTs to learn the focal core practice so that they can better enact responsive teaching are discussed.

Preservice Secondary Teachers' Beliefs about Reformed and Student Centered Teaching: A Comparison of Two Cases

Adam Bennion*, Brigham Young University, USA
Ryan Nixon*, Brigham Young University, USA

ABSTRACT

Understanding the connections between a teacher's knowledge, beliefs, and their practice can help teacher educators better prepare the next generation of science teachers. Preservice teachers' views on important science teaching practices such as eliciting student ideas and focusing on sensemaking can shape the outcomes of their teaching practice and are critical indicators of their "readyness" for the classroom. We ask the question, What are the professed and enacted beliefs that secondary preservice science teachers have about reformed and student centered teaching? We collected data from two cohorts of preservice teachers in the form of surveys, coursework, lesson plans, interviews, and evaluations of teaching enactments. We found that while the overall group's experiences with teaching tended to move the preservice teacher beliefs toward reformed practices, factors such as their practicum and field placement context and their overall focus on either student needs or self-focused concerns (e.g., content knowledge level) made a difference on an individual level.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Research in Approaches to Teacher Preparation
18-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 3

Exploration of Secondary Science Teacher Candidates' Ideological Shifts in an Initial Teacher Preparation Program

Claudia Hagan*, Georgia State University, USA

ABSTRACT

Science teacher candidates (STC) enter an initial teacher preparation program with ideas of what it means to be an educator (Russel & Martin, 2014). Yet, they encounter ideologies about science education for all students that are often different from what they know (Arellano et al., 2016). This study explores how science teacher candidates align or resist the ideologies of social justice and 3D teaching and learning. Teacher candidates encounter ideologies that ask them to question how their instruction and curriculum help students understand themselves, others, power, equity, and anti-oppression (Muhammad, 2020). Using a conceptual framework that combines the Teacher-Centered Systemic Reform (TCSR) model (Woodbury & Gess-Newsome, 2002) and critical theory learning tasks for adults (Brookfield, 2005), the experiences of five science teacher candidates are explored. The research questions that guide this study are: (1) Why do STCs align and/or resist critical science ideologies? (2) How do STCs alter their instructional practice throughout an initial teacher

preparation program? Findings show all participants engaged in four critical adult learning tasks that influenced their ability to align with critical science ideologies. This information will help teacher educators better understand how to challenge their students' ideologies.

Colorado Science Education Research

Impacting Preservice Teachers' Classroom Practice Through the Development of Coherent Science Teacher Education Experiences

Kevin Cherbow*, BSCS Science Learning, USA
Abraham Lo*, BSCS Science Learning, USA
Cari Herrmann Abell, BSCS Science Learning, USA
Karen Askinas, BSCS Science Learning, USA
Betty Stennett, BSCS Science Learning, USA

ABSTRACT

This study mobilized the [PROGRAM] framework to enhance the effectiveness and coherence of the three university science education programs in the Mountain West. We hypothesized that redesigning teacher education programs in ways that foreground the use of the [PROGRAM] framework would positively impact preservice teachers (PSTs) classroom practices as they participated in student teaching. We worked with these universities (A-C) to plan and implement revisions to their science teacher education programs informed by the framework. We recruited PSTs before (Business-As-Usual) and after (Treatment) each team implemented their revisions. We analyzed video of PSTs student teaching and interviews of project participants. To describe the extent to which PSTs' classroom practices included [PROGRAM] strategies, we used a Rasch measurement model to estimate measures of classroom practice. University C had the biggest difference in classroom practice measure between the BAU and treatment groups, which suggested that the implementation of University C's plan impacted PSTs' classroom practice. Each university differed in the duration and scale of their revisions to their teacher education programs. This may have contributed to the variation in each university's average classroom practice score. Overall, this study presents a powerful approach to enhance coherence in science teacher education programs.

Shifting Teacher Preparation for Three-Dimensional Science: Using a Networked Improvement Community to Support Faculty Learning

Corinne Lardy*, California State University Sacramento, USA
Michelle Sinapuelas*, San Francisco State University, USA
Michele Korb, California State University East Bay, USA

ABSTRACT

In 2016, a Networked Improvement Community (NIC) of 11 science education faculty from six universities was formed to facilitate communication and shared expertise among faculty working towards a common goal of improving preservice teacher understanding of the Next Generation Science Standards (NGSS) within secondary and elementary science methods courses. Over the course of seven academic years, NIC faculty met monthly to discuss topics related to teaching secondary and elementary methods courses and conducted science

teacher education research together. Monthly NIC meetings were recorded and annual interviews were conducted with each participant. This paper describes the evolution of the NIC over time and how it served as a professional development vehicle for participating faculty, helping to evolve participants' thinking and practice related to preservice science teacher education and their own understanding of NGSS. Additionally, the NIC was important for developing trust within the community as a safe space for members to discuss emerging topics of preservice science teacher education beyond NGSS, including virtual instruction during the Covid pandemic and incorporating racial and social justice issues into science methods courses.

The Role of Connection-Making and Deeper Learning in Preservice Secondary Science Teachers' Classrooms and Preparation
Matthew Bennett*, UC Santa Barbara, USA

ABSTRACT
This study explores the role that connection-making for deeper learning plays in the classrooms of preservice secondary science teachers and in their teacher education program experiences. Teaching for deeper learning is widely held to be a valuable and integral part of education and teacher education, but there remains a gap in terms of clearly identifying ways in which deeper learning, and more specifically how connection-making as leading to deeper learning, plays a role in secondary science classrooms and their preparation. Preservice teachers in this study participated in four interviews during their one-year teacher education program. Using these four interviews, guided by an understanding of deeper learning and connection-making primarily drawn from How People Learn II (NAP, 2018), and Fries et al.'s (2022) Framework to Guide Instructional Design for Developing Understanding in Complex Domains, this study describes how 9 preservice secondary science teachers learn about and subsequently facilitate opportunities for deeper learning and connection-making in their placements. In examining facilitation practices and trends through the year, I discuss how PSTs demonstrate more developed implementation practices of facilitating connection-making for deeper learning, which leads into potential implications for teacher education programs.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Investigations of Teachers' Professional Vision
18-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 12

Investigating the Relationship Between Science Teachers' Professional Vision of NGSS Practice and Their Implementation
Yuxi Huang*, University of Georgia, USA
Joseph Deluca, University of Georgia, USA
Hong Tran, University of Georgia, USA
José Pavez, Western Illinois University, USA

Julie Luft, University of Georgia, USA
Brooke Whitworth, Clemson University, USA

ABSTRACT
This study explores the relationship between science teachers' professional vision of science and engineering practices (SEPs) and their practices. We utilized a video-based instrument to elicit teachers' responses concerning three SEPs: developing and using models, analyzing and interpreting data, and engaging in argumentation from evidence. Science teachers also reported their usage of reform-based practices for the previous school year via a validated survey. A mixed-method analysis was used to examine the responses of teachers. The results reveal that science teachers' PVSEP and their implementation frequency of the SEP are positively related. In addition, non-science-related knowledge-based reasoning does not have as strong a relationship with SEP-related instructional practices as science-related knowledge-based reasoning does. This finding highlights the critical importance of offering science-specific professional development for science teachers.

Teacher Appreciation of Analysis as an Instructional Use of Big Ideas
Daniel Capps*, University of Georgia, USA
Jonathan Shemwell, University of Alabama, USA

ABSTRACT
Instructional uses of big ideas are underdeveloped in the literature. This lack of precision has led to a gap in our understanding about what teachers should know about the instructional uses of big ideas. In an empirical study, we investigated teachers' reactions to using the big idea of energy transfer which included energy input, storage, and output, and emphasizing effort against a springy resistance, to learn about the biology topic cellular respiration. We use qualitative evidence to show both how teachers appreciated that big ideas support learners to operate on information and how they make information more meaningful. We then discuss how knowing what teachers can appreciate about the instructional benefits of big ideas can be leveraged to support the use of big ideas more broadly in instruction.

The Complex Learning of Science Teachers Within Their Districts: Teachers' Perspectives
Julie Luft*, University of Georgia, USA
Ella Yonai, University of Georgia, USA
Joe DeLuca, University of Georgia, USA
Hatice Ozen, University of Georgia, USA
Elizabeth Ayano, University of Georgia, USA
Yuxi Huang, University of Georgia, USA
Jennifer Bateman, Clemson University, USA
Brooke Whitworth, Clemson University, USA

ABSTRACT
Science teacher learning is complex, and not linear. Teachers learn from their peers, within the school, as they engage with curriculum, and through the work of district leaders. The opportunities to learn exist in a multitude of places. Teacher learning is a complex system

'that involves many processes, mechanisms, actions and elements' (Opfer & Pedder, 2011). This study depicts the complex learning terrain of 23 K-12 science teachers, within their schools and districts, and over a two-year period of time. Interviews at the beginning and end, and during their school year were the data sources. During these interviews, teachers shared the professional learning experiences they had, where their instructional resources came from, as well as discussing who was important to them as science teachers. Their interviews were examined qualitatively in order to understand people and events, and then through a complexity framing. The science teachers experienced learning opportunities that were individualist, additive, complementary, compensatory, or in conflict, and came from a variety of sources. Throughout their professional learning experiences, science teachers were guiding their own learning. Most important were their colleagues and peers in their schools, while the districts provided more uneven learning opportunities.

Connections between Instructional Vision and Rigor Related to Teachers' Support of Students' Productive Science Talk

Patrick Enderle*, Georgia State University, USA
Ruveyde Kaya, Florida State University, USA
Norris Boyd, Florida State University, USA
Sierra Morandi, Florida State University, USA
Elif Ozulku, Florida State University, USA
Danielle Rhemer, Florida State University, USA
Ozlem Akcil Okan, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT

Science teachers' instructional vision entails the images and ideas they personally develop to illustrate their understanding of the work of teaching and has been found to be telling in regard to the instruction they enact. Understanding teachers' instructional vision can be a tool in supporting them as they work to enact high-quality, rigorous science instruction. Our research questions were: What relationships exist between teachers' instructional vision related to productive talk and their enactment of rigorously designed instructional tasks? What relationships exist between different aspects of instructional vision? What relationships exist between different aspects of instructional rigor? The current study involved twelve high school biology teachers participating in a year-long professional development focused on supporting productive science talk. The teachers' instructional vision concerning productive talk was assessed at the end of this experience and compared to observations of the rigor of their implementation of four focal lessons across the school year. Findings demonstrate that although instructional vision may broadly align with teachers' rigor, nuances in teachers' vision related to productive talk can vary in how they sustain productive talk and sensemaking. Variations in the design of instructional tasks complexify how different aspects of instructional vision may guide teachers' teaching.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
New Teachers' Resilience and Retention
18-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 7

Why do Teachers Stay?: A Cross-Case Study of U.S. Novice Secondary Science Teacher Retention
Douglas Larkin*, Montclair State University, USA
Suzanne Patzelt, Touro Univerity, USA
Mayra Muñoz, Montclair State University, USA
Khadija Ahmed, Montclair State University, USA
Liz Carletta, Montclair State University, USA
Manar Hussein, Montclair State University, USA

ABSTRACT
This research reports on the results of a 5-year study undertaken in the United States to better understand the reasons for novice science teacher retention in school districts and other local educational agencies that have demonstrably high rates of such retention. The primary question investigated in this study was, "In districts that have demonstrated comparatively more successful novice secondary science teacher retention, what are the factors that relate to such retention?" Analysis of state-level school staffing data between 2007-2018 from four U.S. states was used to identify districts with exemplary novice science teacher retention, and focus districts (n=13) were selected for qualitative site visits and case study construction. The proposed paper presents the findings of this cross-case analysis of the 13 cases. Our analysis, informed by the framework of teacher embeddedness, yielded 10 distinct categories of factors that influenced teacher retention across the case study districts, including support from departmental colleagues, school/district-level systems and culture of support, compensation, teacher autonomy and agency, specialness of place, and five other factors. Implications of specific aspects of the findings related to the retention of teachers of color and the role of mentoring and induction are discussed.

Exploring the New Science Teacher Practices that Reflect a Growth Mindset.
Elizabeth Ayano*, University of Georgia, USA
Adepeju Prince, Kent State University, USA
Julie Luft, University of Georgia, USA
Shannon Navy, Kent State University, USA
Ella Yonai, University of Georgia, USA

ABSTRACT
This study focuses on the practices that reflect new science teachers' growth mindsets in science classrooms. The study research question is: What distinctive pedagogical practices reflect growth mindsets in new science teachers' classrooms? The study participants are four early-career secondary science teachers in their first five years of teaching. The teachers were

drawn from schools identified as high-needs schools from various regions across the United States (US). This study used priori codes to describe the practices that reflect the new science teachers' growth mindset. Data analysis involved viewing and listening carefully to the video lessons. The coding process began with skimming the assigned observation videos. After viewing the videos, researchers met to discuss our coding and ensure agreement. When there were disagreements in the coding, a specific process was applied to reach a consensus which involved having each coder discuss the selection of codes and listen to the other decisions. Through a consensus process, an agreement was reached on one code. The findings from this study show that the new science teachers' practices in this study mirror growth mindsets. The implications of the study were also discussed.

Contextual Factors and Homegrown Early Career Science Teachers

Adepeju Prince*, Kent State University, USA
Shannon Navy*, Kent State University, USA
Kelly Kulp, University of Georgia, USA

ABSTRACT

Homegrown teachers are an interesting population to examine in the teaching profession. However, little is known about homegrown early career science teachers (ECSTs) who complete teacher preparation programs and choose to go back and teach in their home communities. This paper focuses on the journeys of homegrown ECSTs into the teaching profession and how they relate to the contextual factors in the school community. Findings revealed that homegrown ECSTs eased into teaching because of the familiarity with the school community and had easier collaborations and mentorship with colleagues and school leadership. The study highlights the advantages of homegrown science teachers during recruitment and its important contribution to ECSTs retention in the teaching profession.

From Challenge to Coping: Exploring Resilience Trends and Strategies Among Newly Hired Science Teachers

Jose Pavez*, Western Illinois University, USA
Ella Yonai, University of Georgia, USA
Shannon Navy, Kent State University, USA
Julie Luft, University of Georgia, USA
Adepeju Prince, Kent State University, USA
Lisa Borgerding, Kent State University, USA
Bo Idsardi, Eastern Washington University, USA

ABSTRACT

High rates of teacher turnover adversely impact student outcomes, especially in science. This mixed methods study explored resilience trajectories and coping strategies among 26 secondary science teachers in their first 5 years. Teachers completed Likert surveys on motivation, social, emotional, and professional resilience at the start, mid, and end of one year. Qualitative pre- and end-of-year interviews provided insights into teachers' lived experiences. Quantitative results revealed a "scissors" trend in motivational resilience, with positive trend teachers showing increased motivation over time while negative trend

teachers declined. Interviews highlighted evolving challenges from student engagement to controversial topics, and shifting supports from collaboration to self-care. Irrespective of motivational trends, all faced systemic issues like student apathy post-COVID. The study makes key contributions by revealing multidimensional teacher resilience patterns, including vulnerability in motivation, and providing perspectives on navigating challenges. It informs supporting teacher retention and growth through extended, personalized mentoring and training in resilience. This presentation encourages reflection on practices to support science teacher experiences and stability during the crucial early career stage.

Strand 10: Curriculum and Assessment
Symposium
What Next for Science Standards? NGSS 2.0?
18-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 4

What Next for Science Standards? NGSS 2.0?
Jonathan Osborne*, Stanford University, USA
Andy Zucker*, Independent Scholar, USA
Daniel Pimentel*, University of Alabama, USA
Peta White*, Deakin University, Australia
Douglas Allchin*, University of Minnesota, USA
Penny Noyce*, Independent Scholar & Publisher, USA

ABSTRACT
This symposium will be an opportunity to discuss the major theme of the conference – Science for the Rest of Us. A decade after the inception of the NGSS, this symposium will provide an opportunity to reflect on their strengths and weaknesses. Presenters will offer a range of varied critical and reflective commentaries on how NGSS and other science standards have improved science education to date, and where there are outstanding issues. A basic premise of the presentations will be that any set of standards must define learning outcomes that will be valuable for those who will be non-experts to enable them to better engage with scientific expertise and claims. What can be done to support the development of such capabilities to reduce the epistemic distance between the outsider and the expert, and how might it best be done? What kinds of knowledge will best serve those who will be non-experts and what evidence and arguments best support the case for a rethinking of existing standards both in the USA and elsewhere. The intention of the symposium is to initiate a debate amongst the NARST community and others about what revisions are necessary to produce the NGSS 2.00.

Strand 10: Curriculum and Assessment
Related Paper Set
A Partnership to Advance Earth Science Across Biology, Chemistry, and Physics in a Large District
18-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 5

Centering the Local to Advance a District's Earth Science Teaching Goals Through Research-Practice Partnership
Alan Berkowitz*, Cary Institute of Ecosystem Studies, USA
Lauren Browning, George Washington University, USA
Beth Covitt, University of Montana, USA
Karen Draney, University of California Berkeley, USA
Kevin Garner, Baltimore City Public Schools, USA
Jonathon Grooms, George Washington University, USA
Angela Hood, Cary Institute of Ecosystem Studies, USA
Smriti Mehta, University of California Berkeley, USA
Edmund Mitzel, Jr., Baltimore City Public Schools, USA
Carolyn Parker, American University, USA

ABSTRACT
This is the first paper in a paper set that shares learnings from a research-practice partnership (RPP) centered in a large, urban district in the Eastern U.S. Literature on research-practice partnerships and design-based implementation research frame narrative reflections about our results to date, addressing questions about: 1) identifying our 'problem space,' 2) building 'boundary infrastructure,' and 3) coping with the growth and complexity of a diverse set of stakeholders in achieving 'long-term outcomes.' The team embraced a vision for an interdisciplinary approach to teaching about phenomena in the local-to-global environment through integration of Earth science across the disciplines. Collaboration through several cycles of planning identified as the 'shared problem space' the need for and promise of assessments as drivers of rigorous and responsive 3D teaching in the classroom, and for guiding district-wide professional learning and curriculum revision. We are building 'boundary infrastructure' in the form of shared 'boundary objects' (time-efficient formative and summative 3D assessments) and 'boundary practices' (collaborative design, data collection and revision cycles with researchers, teachers and administrators). Groundwork for achieving 'long-term outcomes' is being laid as we accommodate turnover and growth of our collaborative team.

Understanding Teachers' Perspectives to Help Shape Responsive Partnership and Collaborative Work on Problems of Practice
Lauren Browning*, George Washington University, USA
Beth Covitt, University of Montana, USA
Jonathon Grooms*, George Washington Univrsity, USA
Angela Hood, Cary Institute of Ecosystem Studies, USA

Alan Berkowitz, Cary Institute of Ecosystem Studies, USA

ABSTRACT
This is the second paper in a related paper set. It investigates the role of teacher beliefs within the context of systemic reform at the school district level through a Research Practice Partnership (RPP). Six high school science teachers were interviewed regarding their beliefs about teaching coupled with their articulation of three-dimensional teaching. The results showed that these teachers hold a range of beliefs related to teaching and learning, yet the group fall mostly within Transitional and Responsive categories indicating student-focused beliefs about teaching and learning. Teachers also had varying levels of sophistication in their descriptions of three-dimensional teaching. Overall, results suggest that varying degrees in teachers' beliefs may influence how they take up the key tenets and goals of a systemic reform initiative. We plan to use this initial interview data to guide our RPP going forward through targeted professional learning experiences with teachers.

Centering Science Assessment Resources and Practices to Mediate Discourse in Collaborative Professional Learning

Jonathon Grooms*, George Washington University, USA
Lauren Browning*, George Washington University, USA
Beth Covitt, University of Montana, USA
Angela Hood, Cary Institute of Ecosystem Studies, USA
Edmund Mitzel, Jr., Baltimore City Public Schools, USA
Alan Berkowitz, Cary Institute of Ecosystem Studies, USA

ABSTRACT
This paper explores the role of assessment resources for supporting teacher discourse during a professional learning experience within a research practice partnership. The associated research practice partnership centers on the development of a district-wide assessment system to support high school teachers' rigorous, responsive, and ambitious science teaching. Teacher professional learning experiences center on 'boundary objects' to support discourse and reflection on student learning, classroom practice, and collaborative co-development of assessment resources. This paper reports on the nature of teacher discussion around assessment artifacts and the role of assessment resources in promoting 'boundary spanning' discourse among participants in the research practice partnership, such as teachers, administrators, and researchers.

Co-creating an Assessment System to Meet Teacher and Student Requirements in a Large, Urban District

Beth Covitt*, University of Montana, USA
Jessica Bean, University of California, USA
Lauren Browning, George Washington University, USA
Karen Draney, University of California, USA
David Fischer, Cary Institute of Ecosystem Studies, USA
Kevin Garner, Baltimore City Public Schools, USA
Jonathon Grooms, George Washington University, USA

Smriti Mehta, University of California, USA
Edmund Mitzel, Baltimore City Public Schools, USA
Alan Berkowitz, Cary Institute of Ecosystem Studies, USA

ABSTRACT
This paper, which is part of a related paper set addressing activities and learnings of a research-practice partnership (RPP), reports on collaboration to develop and refine an infrastructure system to support District teachers as they integrate Earth science assessment and instruction into biology, chemistry, and physics courses. The system will include Earth science assessments developed and/or adapted for integration into District science courses, supporting materials and resources such as teacher guides, and an online platform for posting and implementing assessments and accessing responses and reports of assessment outcomes. In undertaking this effort, our RPP is attending to complementary priorities of supporting 3D, NGSS-aligned teaching and learning (including through assessment) and meeting additional concerns and requirements of those in the District (e.g., system facility and security for assessment and grading with large numbers of classes and students). Growing inter-partner understanding of diverse resources, areas of expertise, requirements, and desires is helping the RPP to become more effective in our collaborative efforts. Surfacing and actively discussing and working with the different resources and perspectives is creating a complex and challenging, but also productive boundary space for building new, adapted and adaptive knowledge, practices, resources, and infrastructure (systems) across partners.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set
Centering Multilingual Students' Language Resources and Dynamic Sensemaking Practices in Science Education Research
18-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 16

How Does Translanguaging/Trans-semiotising Support Students Grappling with Uncertainty When Planning Scientific Investigations?
Souhaila Nassar*, Boston University, USA
Eve Manz, Boston University, USA

ABSTRACT
There has been substantial recent interest in how to support students to participate in science practices in ways that are productive, meaningful, and purposeful. One focus has been incorporating uncertainty in science activity to support purposeful engagement in science practices. Both engaging with uncertainty and science practices are linguistically demanding and are often watered down for young children and multilingual learners, especially those from nondominant racial and ethnic groups. This study explores how translanguaging and trans-semiotising support 2nd-grade emerging English learners' engagement in planning a scientific investigation to test whether their seeds travel by

sticking. We conduct a fine-grained analysis of children's interactions with each other, their teacher, the available semiotic resources, and the context. We consider how the teacher and environment invited decision-making and how that supported children's engagement in planning investigations, detailing the central role of translanguaging and trans-semiotising. The findings elicit that children's access to—and use of— materials and multiple languages was central to their engagement in recognizing, making, and discussing choices. We identify practices employed to invite and discuss uncertainty. Finally, we identify ways in which students drew on connections between the materials, their life experiences, and the seeds to make investigation choices.

Developing a Multimodal Assessment System for Science Sensemaking in Elementary Classrooms

Genelle Diaz-Silveira*, Boston University, USA
Eve Manz, Boston University, USA

ABSTRACT

Because elementary and multilingual learners are simultaneously developing language, writing skills, and science understandings or practices, teachers of these students experience especial challenges in equitably assessing their understandings across multiple dimensions of science learning. Here, we reflect on a multimodal assessment system we developed to allow teachers to see children's sensemaking, track their progress on standards, and identify when children need further support. Our study was conducted in an urban school district with a racially diverse student population and 21% of learners classified as ELLs. We created a rubric by specifying a student model of ideas and practices we hoped students might develop, locating and refining tasks that could allow us to observe those understandings and practices, and positing a set of "look-fors." Twenty-five children across two classes engaged in tasks, with 12 additionally engaging in individual interviews. We applied our rubric to classroom discussion, written work, drawings, student interviews, and scientific models, and analytically memoed across modalities and children. We found that written tasks, inviting open-ended graphical representation, and conversational assessment each helped us understand different aspects of children's competence. Additionally, students with whom we conducted one-on-one interviews were consistently perceived to exceed expectations for multiple criteria.

Enactment of Translanguaging Formative Assessment Designs and Consequences for Multilingual Learners' Science Sensemaking

Caitlin Fine*, Metropolitan State University of Denver, USA
Melissa Braaten, University of Colorado Boulder, USA

ABSTRACT

Equitable assessment of student ideas is of central importance to NGSS-aligned science because teachers make consequential instructional decisions based on assessment data. We know that teachers' moves matter for creating equitable sensemaking opportunities for students in science classrooms. Less is known about what teacher moves look like during science formative assessment that incorporate translanguaging practices and how these

moves impact multilingual learners' learning. Consequently, this study addresses the following research questions: How do science teachers and students navigate the enactment of translanguaging formative assessment designs? What are the consequences of this enactment for ML's science sensemaking? An exploratory qualitative case study method allowed us to explore how two experienced science teachers enacted translanguaging assessment designs in a linguistically diverse middle school during the last two cycles of our 9-month participatory co-design project. Through inductive and deductive analyses of formative assessment classroom enactment data, we found that teacher moves both opened-up and stalled opportunities for MLs' equitable sensemaking through translanguaging. This study contributes concrete examples of formative assessment enactment moves that align with translanguaging shifts. Similarly, tensions we identified point to larger structural, cultural and political changes needed within science assessment systems.

Conceptualizing and Measuring Pedagogical Content Knowledge of Language for Scientific Sensemaking

María González-Howard*, The University of Texas at Austin, USA
Sage Andersen, The University of Texas at Austin, USA
Karina Méndez Pérez, The University of Texas at Austin, USA
Carla Robinson, The University of Texas at Austin, USA

ABSTRACT

Current reform approaches to science education call for students to drive the classroom community's scientific sensemaking work, generating knowledge about natural phenomena with peers through language-rich science practices. To address language injustices permeating science learning spaces, it is critical that teachers develop expansive views of language and understand the centrality of language for scientific sensemaking. Our research group's work centers around multilingual students having meaningful opportunities to engage in practice-oriented instruction. Tools for assessing teachers' pedagogical content knowledge (PCK) have been important for determining where teachers' understandings and instructional practices stand to better inform teacher learning experiences. Thus, in this conceptual piece, we describe how we have conceptualized and are in the process of developing an instrument to measure teachers' PCK of language for scientific sensemaking. Grounded in a disciplinary perspective on translanguaging, we are designing items to examine teacher noticing of the ways multilingual students mobilize their full language repertoire - including linguistic (e.g., speaking and writing across named languages) and multimodal (e.g., gestures, graphs, drawings) language resources - without regard to socially constructed boundaries when sensemaking via science practices.

Using Historical Storytelling to Amplify the Voice of Multilingual Learners In High School Science Classrooms

Hosun Kang*, University of California Irvine, USA
Paola Rosenberg, Anaheim Union High School District, USA
Erik Cobian-Mejia, Anaheim Union High School District, USA
Stephen Skoropad*, University of California Irvine, USA

ABSTRACT
This study explores multilingual learners (MLs)' responses to a deliberately co-designed unit about climate change in four 9th grade high school science classrooms. Specifically, we examine MLs' use of languages, other than English, to do science under various instructional conditions, and how the use of language mediates the expansions of MLs' relations or connections among themselves, their community, and the topic of climate change. Data include: a) 93 copies of written assessments that prompted MLs to express their scientific understanding, b) 95 capstone projects that prompted MLs to make a voice about the issues that they cared about, and c) a 55-minutes long teaching video where a teacher engaged in translanguaging. The analysis reveals the contextual- and task-dependent MLs' use of home languages, and its impact on expanding their relations. For example, MLs rarely used home language to communicate their ideas in their written assessments, except the dual language emergent classroom setting. More frequent and various MLs' use of home language was observed in capstone projects– an unconventional assessment (Author and others, 1) designed to support students' civic engagement through storytelling. We found three ways in which MLs expanded their relationships and connections while telling stories using multiple languages.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Recontextualizing Science Education: Reckoning with Wicked Problems and Structural Injustices
18-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 15

Navigating Wicked Problems through intersecting science education and culture: Insights from Ukraine, Estonia, Turkey, Bangladesh

Tapashi Binte Mahmud Chowdhury*, University of Tartu, Estonia
Miia Rannikmäe*, University of Tartu, Estonia
Jack Holbrook*, University of Tartu, Estonia
Maryna Zaluzhna*, Zaporizhzhia National University, Ukraine
Bulent Cavas*, Dokuz Eylül University, Turkey

ABSTRACT
Recent crises such as pandemics, war, economic inflation, refugee influx and natural disasters such as earthquakes have all echoed that culture plays a strong role in determining peoples' response towards wicked problems. While science education aims to promote awareness and preparedness for wicked problems, an isolation of school science from culture results into promoting student image of science as unaccounted for and unaffected by cultural experiences. In reducing such polarisation of science and culture, this study seeks to identify teacher perceptions towards the combined role to be played by both science education and culture in addressing wicked problems. In so doing, this study takes into consideration four wicked problems – the current war in Ukraine, the recent earthquake in

Turkey, refugee influx in Estonia, and reoccurring floods in Bangladesh. Semi-structured interviews have been conducted with 5 volunteering teachers from each country. Results indicate teachers' perception towards roles played by culture and science education separately, and possible ways to combine so as to promote culturally relevant, responsive and adaptive science education. The significance of this study lies in the multi-cultural nature of this research, which have allowed the researchers gain an international perspective from science teachers with first-hand experience with wicked problems.

Racial and Socioeconomic School District Segregation and Secondary Science Outcomes
Christopher Cioffi*, Stony Brook University, USA
Angela Kelly*, Stony Brook University, USA

ABSTRACT
This correlational case study analyzed secondary science performance data to determine how historical racial and socioeconomic segregation may have impacted the quality of secondary science education in suburban school districts (N=44). The theoretical framework for the present study is based upon research in between-school stratification of academic course offerings and performance as related to demographics. Linear regression of college preparatory science performance showed statistically significant relationships between biology and chemistry proficiency and the percentage of economically disadvantaged students in a district, as well as between biology and Earth science proficiency and percentage of English language learners. Analysis of variance tests were also conducted to compare enrollment data and science performance with Advanced Placement (AP) science course offerings as the test factor. Schools with lower socioeconomic status and higher percentages of ethnic minorities in STEM and English language learners were less likely to offer more mathematically rigorous AP science courses. By developing a nuanced understanding of these data, future research may assess how these relationships exist in other suburbs across the United States, which would provide educators with the knowledge and perspective that may allow for targeted reforms to address the meaningful reduction of inequality in suburban science education.

The School-to-Prison Pipeline: Teacher's Perspectives
Maizie Dyess*, University of Nevada, Las Vegas, USA

ABSTRACT
Students of color are being disproportionately surveilled, disciplined, and excluded from public education in schools across the country, and ultimately referred to law enforcement. This phenomenon, known as The School-to-Prison pipeline, refers to the convergence of outdated and color-evasive educational policy with a predominantly penal juvenile system. Teachers in this study identified racial disparities within the School-to-Prison Pipeline and the Juvenile System, but failed to identify racial disparities within discipline and schooling practices. Research has suggested that K-12 teachers need to explicitly acknowledge and disrupt oppressive structures in both science and education in order to teach for goals of social justice and to combat the predominantly white and masculine culture of science itself. This study addresses the themes identified after 15 teachers were surveyed regarding The

School-to-Prison Pipeline, discipline within schools, and the juvenile system. A toolkit was created following the completion of this study, for teachers and community members, with the intention of providing resources aimed at addressing the findings.

Modelling Equity in Science Education: German Street Schools' Approach to Rightful Presence

Matthias Fischer*, Heidelberg University of Education, Germany
Angela Calabrese Barton, University of Michigan, USA

ABSTRACT

Approximately 30% of all homeless students in Germany drop out of school early. This corresponds to five times the average dropout rate in Germany. This graduation gap can be explained, among other things, by their experiences of marginalization and exclusion in the German school system. Many young people go on to obtain their school-leaving qualifications at so-called street schools, which focus their educational approach on the educational needs of these young people and thus see themselves as an alternative to the mainstream school system. The success rates of the street schools show that they are quite successful with their approach and consequently promote educational equity. We conducted interviews with principals and educators of the street schools to investigate their educational concept. In our study, we use the Rightful Presence Framework to show the extent to which street schools implement a science education that does not further exclude homeless youth, but rather is socio-politically and personally relevant to them. Our findings show that street schools are redesigning science education while consciously challenging pre-existing structures of the mainstream school system.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set
Technology for Science Learning 1
18-Mar-24, 10:00 AM-11:30 AM
Location: Directors Row H

Analyzing the Performance of Chemistry Students and ChatGPT on Acid-Base Calculations

Ted Clark*, The Ohio State University, USA

ABSTRACT

Student performance on open-response calculations involving acid and base solutions before and after instruction in general chemistry and analytical chemistry courses was compared with the output from the artificial intelligence chatbot ChatGPT. Applying a theoretical model of expertise for problem solving that includes problem conceptualization, problem strategy, and solution, it is found students errors following instruction primarily involved problem conceptualization and the misapplication of heuristics like the Henderson-Hasselbalch equation When the same problems were used as input to ChatGPT the responses were comparable to worked examples found in general chemistry textbooks in terms of length and detail and usually displayed strong problem conceptualization.

Response accuracy of the chatbot varied greatly for different topics, being best for calculations of pH for a strong acid or strong base and much lower for more complex problems involving titrations or aqueous salts. Chatbot and student errors differed in that the chatbot did not misapply heuristics, but did make mathematical errors uncommon for students. The variability in the correctness of ChatGPT's responses and the nature of its errors vis-à-vis students will influence its potential use as an instructional resource for calculations involving acids and bases.

Mapping New Possibilities in Elementary Science: Expansive Data, Participatory Digital Map Making, and Science Argumentation

Kathryn Lanouette*, William & Mary, USA
Sarah Van Wart, University of North Carolina, Asheville, USA
Tapan Parikh, Cornell Tech, USA

ABSTRACT

There has been an increasing focus on digital mapping technologies in education research yet to date, there has been limited study of such technologies within science education and with children. In this study, we examine a multi-year design research project that centered 4th and 5th grade students learning about socio-ecological systems using participatory digital maps to study their schoolyard soil ecosystems. Analyzing video of whole class discussions, we show how children used their maps to juxtapose varied data types and layers to conjecture and contest claims and evidence. We find that children were able to reason about complex socio-ecological systems in complex ways, while also expanding what forms of evidence could be brought to bear in elementary school science discussions.

Connecting Representational Levels by Using Augmented Reality (AR) During Chemical Hands-on Experiments – a Mixed-Methods Study

Hendrik Peeters*, Paderborn University, Germany
Sebastian Habig, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
Sabine Fechner, Paderborn University, Germany

ABSTRACT

Chemistry education involves explaining scientific phenomena, where the submicroscopic level holds entities responsible for observable changes, even though they are not visible. Integrating these levels of representation is challenging for students, possibly due to the separation of observation and interpretation. Augmented reality (AR) technology addresses this issue by augmenting real-world environments with virtual models during hands-on experiments, bridging the macroscopic and submicroscopic levels. A study investigated the impact of AR on linking different levels of representation in student-generated explanations of chemistry experiments. 104 German secondary school students were divided into three intervention groups: AR, animation, and filmstrip. Each group performed and explained two hands-on experiments. The AR group used an AR app with virtual models during the experiments, while the other groups were given the same models afterwards. Students recorded explanatory videos after preparing their explanation with the help of a prepared template by capturing their iPad screens. Preliminary results suggest that, in general, most

students were not able to link the different levels of representation in their explanations in a structured way. However, the AR group produced more high-level explanations for the second experiment compared to the other groups.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Symposium
The Nature of Engineering: Exploring Key Questions to Move Research Forward
18-Mar-24, 10:00 AM-11:30 AM
Location: Directors Row J

The Nature of Engineering: Exploring Key Questions to Move Research Forward
Jacob Pleasants*, University of Oklahoma, USA
Allison Antink-Meyer*, Illinois State University, USA
Sevgi Aydin-Gunbatar*, Yuzuncu Yıl University, Turkey
Gillian Roehrig*, University of Minnesota, USA
Miriam Barak*, Technion, Israel
Sibel Erduran*, Oxford University, United Kingdom
Hasan Deniz, University of Nevada, Las Vegas, USA
Erogan Kaya*, George Mason University, USA
Ezgi Yesilyurt, Weber State University, USA

ABSTRACT
Over the past decade, there has been a growing emphasis on pre-college engineering education as part of broader STEM education efforts. Amid the larger body of scholarship on pre-college engineering education, there is a growing body of research that focuses on the Nature of Engineering (NOE), which describes engineering as a distinctive human endeavor. This symposium will bring together scholars who have made recent contributions to NOE research. Participants have developed NOE frameworks, research tools, and explored the teaching and learning of the NOE through empirical studies. Though there are areas of convergence within their work, there are also distinct differences in the perspectives the researchers bring. The goal of this symposium is therefore for participants to engage with those different perspectives around a set of key questions that concern how the NOE as a research area might be advanced. Key questions include what NOE aspects ought to be prioritized, what approaches ought to be used to teach the NOE, and how the NOE ought to be assessed. The symposium aims to foster critical engagement and dialogue, identify new and promising lines of inquiry, and further develop shared understandings of the NOE as a burgeoning area of research

Strand 14: Environmental Education and Sustainability

SC-Organized Paper Set

Education for Sustainable Development

18-Mar-24, 10:00 AM-11:30 AM

Location: Directors Row I

Evaluating Student Engagement in Climate Change Education: A Novel Approach to Measuring Environmental Science Agency

Jeffrey Snowden*, BSCS Science Learning, USA
Brian Donovan, BSCS Science Learning, USA
Lindsey Mohan, BSCS Science Learning, USA
Emily Harris, BSCS Science Learning, USA

ABSTRACT

Environmental Science Agency (ESA) is a framework that emphasizes the importance of young people leveraging their science learning and participation as a basis for acting on environmental sustainability issues. We are partnering with teachers to design localized climate learning experiences that attend to student interest, identity, expertise, and content knowledge within science classrooms. As part of an ongoing research study, we are using a novel ESA measurement framework to explore how such learning experiences impact the extent to which students leverage their classroom experience as a foundation for the current or future ability to act on environmental sustainability issues in their life or community. We developed and validated three instruments that assess student knowledge of climate change, interest and identity in science, and enjoyment of science roles in the classroom. Using hierarchical random intercept models, we explored the predictive validity of these constructs on students' foundations for change. Significant within-classroom effects were found for all three measures, underscoring the influential role of teachers in positioning students within their classrooms to foster ESA. Our findings provide validity evidence for the novel ESA measurement framework which emphasizes the complex interplay of knowledge, roles, and identity in shaping students' foundation for environmental change.

Fostering Learners' Action Competence to Deal With the Global Environmental Issue of Insect Decline

Peter Lampert, Karlstad University, Sweden
Daniel Olsson*, Karlstad University, Sweden
Niklas Gericke, Karlstad University, Sweden

ABSTRACT

Insects play a highly important role for both humans and ecosystems. The ongoing declines in pollinators and other insect groups have become a pressing environmental issue, largely due to human actions. Providing effective education to raise awareness about insect decline and to cultivate learners' ability to address this global challenge is crucial. However, empirical evidence on the impact of educational approaches within formal education on learners' capacity to address the issue of declining insect biodiversity remains limited. Therefore, this presented study focuses on evaluating the effects of an educational intervention within a secondary school setting on students' self-perceived competence to engage in insect conservation efforts. The study investigates the development of this self-perceived competence both quantitatively and qualitatively in a pre-post design. The findings indicate that the intervention led to large increases of the self-perceived action competence to sustain insect biodiversity by fostering students' self-perceived knowledge, confidence, and willingness to take actions. In conclusion, this study provides compelling evidence for the effectiveness of education building on action competence. The study can support both educational scientists and practitioners in designing research and teaching projects that aim to foster learners' competence to deal with complex environmental issues.

Hope and Ecological Identity: Exploring Pathways from Inner to Sustainable Development

Jhu-Chun Yang*, National Sun Yat-sen University, Taiwan
Paichi Pat Shein*, National Sun Yat-sen University, Taiwan

ABSTRACT

The current global landscape is marked by a range of environmental crises; however, a there exists a significant gap between people's knowledge and action. While individuals recognize the urgency of environmental issues, they struggle to transform this awareness into pro-environmental behaviors in their daily lives. To inspire action, it's crucial to initiate change from within—through emotions and identity—by fostering inner development. This study aims to examine the differences in ecological identity, environmental emotion, and environmental philosophy between the general public and professionals and volunteers in environmental education or protection. A total of 90 valid surveys were collected using the snowball sampling approach, targeting the general public and professionals and volunteers in environmental education and protection. We found that when facing environmental issues or climate change, the general public in Taiwan tends to lean towards an external locus of control, believing that someone other than themselves will solve these problems. Taiwanese professionals and volunteers in environmental education and protection exhibit higher levels of ecological identity and nature relatedness compared to the general public. The implications drawn from this study hold significance for fostering pro-environmental behaviors and advancing sustainable development initiatives.

Participatory Photography with Urban Middle School Students: Their Connectedness to and Perceptions of Nature

Andrea Moeller*, University of Vienna, Austria
Petra Bezeljak Cerv, University of Vienna, Austria
Bruce Johnson, University of Arizona, USA

ABSTRACT

Within an Education for Sustainable Development (ESD) context we explored the perception of urban middle school students' (n = 108, 6th grade, age 11-13) representations of nature using participatory photography and their nature connectedness. In a mixed method study applying the "Inclusion of Nature in Self" (INS) scale, we investigated 1) what are middle school students' perceptions of nature as evidenced through their own photography, 2) what

are the differences between students who are more connected with nature and those who are less connected and 3) how can photography be used as a tool to investigate students' perceptions of nature? Participants were asked to take a photo of what nature is to them and write a short description of what is in the image. Their nature perceptions were diverse, with a majority showing plants and nature close to home. Students mentioned positive emotions and aesthetic aspects of nature. Those with a high INS score, defined as more connected to nature, photographed a greater diversity of phenomena and geographies, many outside of urban areas. Participatory photography proved to be an excellent choice for an inclusive data collection method in ESD, especially for students with reading or writing difficulties or language barriers.

Social Event

Awards Luncheon

18-Mar-24, 11:15 AM-1:15 PM

Location: Plaza Ballroom ABC/DEF

Keynote Address

Building A Technology Future for the Rest of Us

18-Mar-24, 1:15 PM-2:00 PM

Location: Plaza Ballroom ABC/DEF

Building A Technology Future for the Rest of Us

Charlton McIlwain

ABSTRACT

Author of the recent book, Black Software: The Internet & Racial Justice, From the Afronet to Black Lives Matter, Dr. Charlton McIlwain is Vice Provost for Faculty Development & Engagement at New York University and Professor of Media, Culture, and Communication at NYU Steinhardt. He works at the intersections of computing technology, race, inequality, and racial justice activism. He has served as an expert witness in landmark U.S. Federal Court cases on reverse redlining/racial targeting in mortgage lending, and recently testified before the U.S. House Committee on Financial Services about the impacts of automation and artificial intelligence on the financial services sector, among other consultative work with the White House and other government agencies and civil society organizations. He writes regularly for outlets such as The Guardian, Slate's Future Tense, MIT Technology Review and other outlets about the intersection of race and technology. McIlwain is the founder of the Center for Critical Race & Digital Studies, heads NYU’s Alliance for Public Interest Technology, is NYU’s Designee to the Public Interest Technology University Network, and is President of the board member at Data & Society Research Institute.

Contemporary Methods RIG
Sponsored Session
Epistemic Network Analysis (ENA): A Tool for Providing Nuanced Perspectives in STEM Education Research
18-Mar-24, 2:00 PM-3:30 PM
Location: Governor's Square 11

Epistemic Network Analysis (ENA): A Tool for Providing Nuanced Perspectives in STEM Education Research

ORGANIZERS
Glenn Dolphin, University of Calgary, Canada
Robert Talbot, University of Colorado Denver, USA
Joseph Taylor, University of Colorado, Colorado Springs, USA
Stanley Lo, UC San Diego, USA
Francesca Williamson, University of Michigan, USA
Brock Couch, University of New Hampshire, USA

PANELISTS
M. Shane Tutwiler, University of Rhode Island, USA
Reagan Siggard, Utah State University, USA
Denise Bressler, DB Engagements, Inc., USA
Amanda Peel, New Mexico State University, USA
Shifath Bin Syed, Texas Tech University, USA
Mark H. Newton, East Carolina University, USA

ABSTRACT
Innovative STEM learning environments have led to a proliferation of multidimensional data that is collected about learners and their learning process. Oftentimes, the connections that emerge from these data lack holistic explanation. Using epistemic network analysis (ENA), we can explore qualitative and quantitative connections between learners and their environment and the intricacies of change in affect and practice over time. In other words, ENA provides nuanced perspectives on rich qualitative data unachievable with certain established methods.
During this symposium, we will introduce the NARST community to ENA, a freely available online tool that can handle the multidimensional and relational phenomenon that can occur for different individuals or groups under various conditions in STEM environments. Then, engaging with presenters who have worked with this user-friendly analytical tool will enable attendees to expand their understanding of a method that utilizes both big data and qualitative understandings to answer pressing educational issues. Finally, a lively discussion among presenters and attendees will solidify the future of ENA within the NARST community.

Latino/a RIG (LARIG)
Sponsored Session
Latinx Science Education Scholarship in Formal and Informal Contexts
18-Mar-24, 2:00 PM-3:30 PM
Location: Plaza Court 2

Latinx Science Education Scholarship in Formal and Informal Contexts

ORGANIZERS
Angela Chapman, UTRGV, Edinburg, TX, USA
Alejandro Gallard, Georgia Southern University, USA

PANELISTS
Miriam Ortiz, UTRGV, Brownsville, TX, USA
Uma Ganesan, UTRGV, Brownsville, TX, USA
Joe DeLeon, UTRGV, Edinburg, TX, USA
Liliana Garcia, UCSB, Santa Barbara, CA, USA
Angela Chapman, UTRGV, Edinburg, TX, USA

ABSTRACT
This session will include a diverse group of panelists who are conducting research in communities, policy, teaching and learning that directly or indirectly effect Latinx learners. The panel discussion will explore tensions and challenges experienced by Latinx and non-Latinx researchers. Also, the work of panelists researching contextually situated science teaching and learning will be discussed. Empirical and theoretical modes of research from different perspectives will be unpacked. For example, the perspectives of being non-Latinx science education researchers' understanding of a Latinx community as juxtaposed to that of a Latinx science education researcher conducting research on Latinx learners. The insider/outsider perspective will be explored. Also, policy implications that affect the teaching and learning of science of Latinx students will be discussed. Additionally, another area that will be explored is how Latinx scholars are positioned by the hegemony of dominant paradigms that maintain the status quo.
The purpose of the LARIG-sponsored session is to provide a platform for NARST members to share their perspectives and experiences in science education research involving learners and/or educators who are Latinx.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
Attitudes, Motivation, and Engagement
18-Mar-24, 2:00 PM-3:30 PM
Location: Directors Row H

Perceived Competence and Choice as Predictors of Students' Intrinsic Motivation

Moonika Teppo*, University of Tartu, Estonia
Regina Soobard, University of Tartu, Estonia
Miia Rannikmäe, University of Tartu, Estonia
Priit Reiska, Tallinn University, Estonia

ABSTRACT

A decline in student intrinsic motivation is an ongoing concern in STEM (science, technology, engineering and mathematics) education, especially during adolescence. Based on self-determination theory (SDT), autonomy, competence as well as relatedness are seen as crucial psychological needs to be supported and satisfied for enhancing intrinsic motivation. This study examines associations between, students' intrinsic motivation (in terms of interest/enjoyment), perceived competence, and perceived choice toward science learning over a three-year period. Data has been collected from 171 lower secondary school students who completed a self-reported questionnaire twice - first in grade 6 and three years later in grade 9. Structural equation modelling (SEM) shows that perceived choice has significantly positive effect both on intrinsic motivation and perceived competence in grades 6 and 9, however perceived competence has no predictive effect on intrinsic motivation not in either grade. Based on the results it is suggested to increase students' intrinsic motivation by enabling more perceived choices in science learning, which in turn promotes the feeling of autonomy.

Measuring Interest During a Student Lab Visit: A Question of Situation or Disposition?

Xenia Schäfer*, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany
Sebastian Habig, Friedrich-Alexander-Universität Erlangen-Nürnberg, Germany

ABSTRACT

The need for tailored science education that highlights competencies, but also motivation and interest, is essential in an era of declining interest in STEM subjects. This study evaluates the dynamics of interest within a student lab as informal science learning environment, utilizing Krapp's person-object-conception of interest and the RIASEC+N-model of interest dimensions during science activities. We aim to assess how interest varies depending on the lab activity and detect the proportion of interest attributed to personal disposition versus situational elements during typical lab exercises. Implementing a single day experience sampling methodology, we measure interest in real-time during lab activities, mapping them to the RIASEC+N-model. Initial findings from a study involving 420 German secondary school students suggest that individual interest in chemistry significantly influences situational interest during activities. Variance decomposition based on a latent state-trait analysis indicates that individual interest dominates over situational interest components during activities. Future work aims to refine the latent state-trait model and to identify learning environment characteristics impacting the situational characteristics of interest. This might contribute to the development of more inclusive and effective student laboratory programs and a move away from the 'one-size-fits-all' approach in informal science education.

Learning From Highly Relevant Topics: Students Interest and Engagement

Natasha Segal*, Wiezmann, Israel
David Fortus, Wiezmann, Israel

ABSTRACT

Despite research indicating the importance of relevance and interest to students' learning, most science instruction is structured around scientific ideas in each discipline rather than around phenomena that are interesting and important to students. SSI-based instruction can support the construction of science learning, while making science relevant and interesting for students (Sadler et al., 2016). Topics of Wonderment (ToWs), are issues that can capture students' interest and awe, and motivate engagement. We hypothesized that if an SSI unit were taught at the beginning of the school year and a ToW unit at the end of the school year, with traditional instruction occurring between these two units, we would expect high levels of interest, engagement, and learning at the beginning and at the end of the school year, with lower levels in between. In this study we developed an SSI and a ToW unit, both for 7th grade. Using interviews and pre-posttests, we investigated the impact of learning science through these two units on students' interest, engagement and science knowledge. The results show (A) a strong connection between engagement and interest and (B) that SSI and ToW units have the potential to raise students' situational interest in relation to traditional instruction.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Related Paper Set

"The truth is, there's just no time": Embracing Interdisciplinary Approaches to Elementary Science

18-Mar-24, 2:00 PM-3:30 PM

Location: Plaza Court 4

Engineering Integration in Elementary Classrooms

Christa Haverly*, Northwestern University, USA
Alexandre Brunet, Northwestern University, USA
Elizabeth Davis*, University of Michigan, USA

ABSTRACT

Relative to other modes of integrating science across subject areas, integrating science with engineering can get expensive and feel like adding content rather than merging subject areas to be more efficient with instructional time. Yet, current reforms argue for including engineering and/or integrating science and engineering starting as early as pre-kindergarten. This paper explores elementary engineering integration in thirteen school districts across the U.S. We wanted to know more about how educators (including district leaders, school leaders, and teachers) are integrating engineering, and who is making decisions about what that integration should look like. Our findings illustrate several models

of engineering inclusion or integration happening across districts that are putting in effort to improve elementary science instruction, while also illuminating the fact that even in these districts, many are still not attending to engineering in classrooms. These models may serve as educative examples for other districts seeking to build an elementary engineering education program. However, they also illustrate a lack of attention to care and empathy, critical for engineering for justice, and something science educators and policymakers must attend to in future science education research, development, and reforms.

Culturally Sustaining and Responsive Education in Elementary Science Teacher Education: Developing Preservice Teachers' Critical Consciousness

Tia Madkins*, The University of Texas at Austin, USA
Sonnur Ozturk, The University of Texas at Austin, USA
Allison Skerrett, The University of Texas at Austin, USA

ABSTRACT
Current national and international discussions in both scholarly and public-facing venues underscore the prevalence of racist ideologies and stereotypes and their influence on individuals' daily lived experiences based on their racialized, ethnic, gendered, and/or other sociocultural identities. In science education, some of these conversations have centered how minoritized learners' experience science teaching and learning, especially young children in PK-5 settings, where they often encounter anti-Blackness, anti-Indigeneity, and differential opportunities to learn. In response, stakeholders have long advocated for science instruction where PK-5 minoritized learners 1) have their cultural, linguistic, and other repertoires of practices viewed as resources for learning rather than deficits; 2) grapple with and challenge power and oppression in science education, schooling, and society; and 3) use science knowledge for empowerment. Engaging in this kind of teaching—teaching science as a pathway to pursue justice and advocate for all children's civil rights—is difficult but important work. To this end, we use culturally sustaining and relevant education (CSRE) as a framework to examine efforts of its role in shaping learning experiences that facilitate the development of a critical consciousness and deeper understanding of equity among preservice teachers.

Supporting Preservice Teachers Shift Their Focus Beyond the Content by Pursuing Equity Through Participatory Science

Terrance Burgess*, Michigan State University, USA

ABSTRACT
Considering calls for elementary teachers to "seek opportunities to continue to build their expertise in working toward equity and justice in their science and engineering teaching," this study focuses on the utility of youth participatory science in elementary science methods instruction as a promising opportunity. Although equity in science education is conceptualized in myriad ways, this study considers equitable science instruction to be both a racialized and politicized endeavor which centers the lives of those historically marginalized in its name for the promotion of justice. Additionally, such instruction acknowledges the holistic perspectives and epistemologies embodied by its consumers while committing to

doing no harm. Given the promise of impact of engaging in anti-racist and equitable science instruction in the elementary grades, this study shifts its focus to preservice elementary teachers (PSTs). Situated in a science teaching methods course, we utilized Morales-Doyle and Frausto's (2019) Youth Participatory Science Framework (YPS) to identify and address a local social justice science issue while amending existing curriculum materials to model how elementary teachers can support student learning and community agency in their future classrooms.

Civic Science Education in Pursuit of Scientific Literacy: A Sustainable Path for Elementary Science Education

Maggie DeMarse*, Michigan State University, USA
E. Woo*, Michigan State University, USA

ABSTRACT

The Next Generation Science Standards (NGSS) pushes for an education in STEM that prepares citizens to make informed personal and civic decisions, which require a scientifically literate populace. Specifically, science education aims to provide all students with the background to systemically investigate issues related to their personal and community priorities. Providing students with this informed perspective requires us to understand the greater implications of science in our daily lives. Through an exploratory grounded theory approach, this comparative case study centers the experiences of two veteran interdisciplinary (science and social studies) teachers to better understand how a civic science approach to instruction impacts scientific literacy among students and teachers. Early findings reveal a developing student agency around broader issues within the community.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

SC-Organized Paper Set

Life Science Teaching and Learning

18-Mar-24, 2:00 PM-3:30 PM

Location: Governor's Square 17

Conjectural Anticipation and the Animating Power of Big Ideas for Agency in Science Learning

Jonathan Shemwell*, University of Alabama, USA
Daniel Capps, University of Georgia, USA

ABSTRACT

Student agency depends on control within classroom activities but also on some sort of animating power by which efforts are motivated and directed toward learning. John Dewey reasoned that 'conjectural anticipation,' comprising expectations about relationships, was the seat of this animating power. We propose that conjectural anticipation is a useful concept for science education. In this field, animating forces of agency are sought in the

learning environment and in students' prior experience, but largely overlooked in the big ideas whose abstract structures are meant to shape student understandings of domains. In a qualitative study, we show how the abstract structure of one big idea, energy, enables conjectural anticipation and agency when learning about cellular respiration in 9th-grade biology.

Testing a Design-Oriented Cross-Domain Teaching Process as a Learning Opportunity for Acquiring Biological Knowledge

Markus Reiser*, University of Education Weingarten, Germany
Martin Binder, University of Education Weingarten, Germany
Holger Weitzel, University of Education Weingarten, Germany

ABSTRACT

In the context of STEM education, we present a cross-domain teaching approach that harnesses the development of technical solutions to facilitate the acquisition of biological knowledge. To achieve this, we propose a model that illustrates how biology and technology can complement each other in a cognitive process that involves identifying similarities in working methods and considering content-related structural and functional relationships. Building upon this model, we have created instructional materials centered around the 'musculoskeletal system' topic. Subsequently, we conducted a study involving 413 students ($M = 12.53$, $SD = 0.818$) to investigate the impact of a design-oriented development process on the acquisition of biological knowledge.
Employing a quasi-experimental mixed-design study, we compared the design-oriented approach with two alternative methods. The first involves students constructing a product based on provided instructions. The second approach involves students exploring structural-functional connections using different biological phenomena.
The findings from both longitudinal and cross-sectional analyses underscore the potential of design-oriented approaches over the two comparative methods, revealing significant differences in long-term learning outcomes. Additionally, these results demonstrate that students exhibit a notably improved understanding of concepts related to the musculoskeletal system through the design-oriented approach.

Can the Culturo-Techno-Contextual Approach (CTCA) Dissolve Barriers to Learning Variation and Evolution?

Rose Agholor*, Science Education Consultant, USA
Peter Okebukola, Lagos State University, Nigeria
Franklin Onowugbeda, Lagos State University, Nigeria
Adekunle Oladejo, Lagos State University, Nigeria
Juma Shabani, University of Burundi Doctoral School, Burundi

ABSTRACT

Since the mid-19th century, the quest for more potent methods of bolstering students' performance in science has become unstoppable and irresistible. Two research questions were addressed in this extract of a larger, 2019 study on CTCA. These were (a) What topics in the new biology curriculum do students find most difficult to learn?; and (b) Is there

statistically significant difference in the achievement of students in the biology topic that is perceived to be most difficult to learn when taught using CTCA and their control counterparts? The study had a survey and a quasi-experimental phase. In the quasi-experimental phase both experimental and control classes were subjected to pretest and posttest using the same achievement measure. In the experimental class, the teacher followed the five-step CTCA protocol. ANCOVA data showed that the experimental and control groups were significantly different (mean score for experimental = 20.18; control=16.08; [$F(1, 68) = 15.40$; $p < .0001$]. Follow-up quantitative probe showed interesting results which support the growing empirical evidence in favor of CTCA as a novel direction for breaking barriers to students' learning of difficult concepts in science and a possible tool to set teaching methods within culturally-relevant and technologically appropriate contexts.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Understanding Impacts of Identity and Experiences
18-Mar-24, 2:00 PM-3:30 PM
Location: Plaza Court 5

Does Religious Identity Impact the Efficacy of Evolution Instruction With Cultural Competence?

Rahmi Aini*, Middle Tennessee State University, USA
Baylee Edwards, Arizona State University, USA
Sara Brownell, Arizona State University, USA
M. Elizabeth Barnes, Middle Tennessee State University, USA

ABSTRACT
This study examined the impact of religious cultural competence in evolution education and whether the religious identity of instructors and students affected its efficacy. Using a randomized controlled trial experimental design, 2,625 undergraduate biology students from 11 different states were randomly assigned to one of three conditions: a control group that received no cultural competence, and two intervention groups that received culturally competent instruction from an instructor who either disclosed a Christian or non-religious identity. Results showed that students who received cultural competence were more likely to increase their acceptance of human evolution, perceive greater compatibility, and experience less conflict between evolution and religion compared to the control group. All student groups showed positive outcomes after receiving evolution instruction with cultural competence from both a Christian and non-religious instructor. The study found that non-religious instructors have a greater impact for non-religious students in reducing perceived conflict between evolution and religion. Additionally, positive effects of a Christian instructor using cultural competence were also observed. Future research could explore the benefits of instructors concealing their religious or non-religious identity in religious cultural competence instruction.

Are Experiences and Trajectories of Black Students Impacted by the Relationship Between Religion and Science?

Elizabeth Barnes*, Middle Tennessee State University, USA
Angela Google*, University of Rhode Island, USA
Julie Park, University of Maryland, USA
Keon McGuire, Arizona State University, USA
Robert Palmer, Howard University, USA

ABSTRACT
In efforts to increase the participation of students of color in biology programs, biology education research focuses on illuminating and improving student experiences. Black students are vastly underrepresented in academic biology. Further, there is a pervasive narrative of conflict between religion and science in society and within academic biology, but Black students identify as Christian at higher rates than any other racial/ethnic group in biology. This means that both Christian and non-religious Black students may have experiences related to their religious identity that may draw them in or push them out of academic biology. Since college is important for socialization into a discipline and Black students are likely to experience stigmatization of their racial and religious identities in biology, we explored their experiences. Surprisingly, we found that both religious and non-religious students see their beliefs as supporting their science identity development but that both groups see a conflict between religion and science in areas of evolution and bioethics. These results indicate that both religious and non-religious identities potentially support the development of students' science identities but that instructors may improve students' experiences by using religious cultural competence when teaching evolution and bioethics topics.

Am I Represented? Validation of an Instrument to Assess Undergraduate Representation in STEM Courses

Hai Nguyen*, University of Missouri-Columbia, USA
Marcelle Siegel, University of Missouri-Columbia, USA
Megan Hirni, University of Missouri-Columbia, USA

ABSTRACT
This research focuses on how students perceive their own representation within STEM fields in higher education, particularly in relation to aspects like ethnicity, race, and gender. To address this, we developed a survey tool capable of gauging the perceptions of STEM college students regarding their experiences within classrooms and across campus. Through the utilization of bifactor analysis for graded response data, a model comprising 12 items was successfully confirmed. Within this study, two underlying traits emerged, shedding light on the latent traits of positive and negative self-perception of representation, which contribute to the overall inclusivity of STEM learning environments. The findings underscore the significance of this study's survey instrument, which not only identifies whether students generally feel represented or not, but also provides deeper insights into their perceptions of support, constraints, and avenues for personal growth. This work will be of interest to NARST members and academics interested in analyzing equitable learning environments because it can inform inclusive teaching, professional development, and research in STEM fields.

Strand 6: Science Learning in Informal Contexts
Symposium
Exploring Emotions in Informal Science Learning
18-Mar-24, 2:00 PM-3:30 PM
Location: Governor's Square 16

Exploring Emotions in Informal Science Learning
Luisa Massarani*, Brazilian Institute of Public Communication of Science and Technology; Casa de Oswaldo Cruz, Fiocruz, Brazil
Neta Shaby*, University of Southampton, United Kingdom
Nancy Staus*, Oregon State University, USA
Shawn Rowe*, Oregon State University, USA
Graziele Scalfi*, Brazilian Institute of Public Communication of Science and Technology; Casa de Oswaldo Cruz, Fiocruz, Brazil

ABSTRACT
Emotions play an important role in learning, in all contexts of life. While once viewed as a hindrance to cognition, we now understand that such emotions play a critical role in the learning process by directing attention, memory, motivation and decision-making in ways that significantly influence learner outcomes. Although emotions are a powerful component of learning, they are under-theorized and under-researched. There is a growing interest amongst researchers regarding emotions that are shared by informal environment practitioners, particularly science centers and museums, especially since experiences in those settings are known to trigger a variety of emotions. The future of research and practice in ISL requires a better understanding of the critical role that emotion plays in learning in a variety of ISL settings in order to inform the design of activities that generate emotional experiences that support successful outcomes for diverse groups of learners. In this symposium we will introduce the importance of understanding the role of emotion in ISL and the challenges of measuring emotion in ISL contexts. We will share insights from research on emotions in ISL that will be the basis for a discussion on critical questions about emotion research and different approaches to emotion research.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Exploring Knowledge and Nature of Science in Preservice Teacher Education
18-Mar-24, 2:00 PM-3:30 PM
Location: Plaza Court 1

Preservice Teachers' Views on Astronomy Through the Lens of Science Storybooks
Julia Plummer*, The Pennsylvania State University, USA
Andrea Ragonese*, The Pennsylvania State University, USA

ABSTRACT
The present study was conducted in a classroom of preservice elementary teachers, in their first two years of postsecondary education. The goal of the study was to evaluate how preservice teachers enact social justice and anti-deficit perspectives in astronomy education. As a final course project, the students (N=24) wrote a children's astronomy storybook for elementary-aged children, demonstrating their understanding of the questions: Who does astronomy? What counts as doing astronomy? and, Where is astronomy done? Using thematic analysis, we found that many students included main characters who are people of color and/or women; many students also depicted characters engaged in science practices. We also found that many students stated astronomy can be done by anyone or in any place but did not support these assertions through how they depicted characters or places in their storybooks. In addition, many students depicted traditional views of science (e.g., learning facts) and depicted characters who lacked agency in their own science learning. Our findings suggest that future teachers need support to develop a more critical lens on science education and children's literature to ensure they are addressing the needs of all students in their classroom.

Pre-service Teachers and Socioscientific Issues: Their Views and Creation of Issues-Based Science Lessons

Savannah Graham*, University of Houston, USA
Hayat Hokayem, Texas Christian University, USA

ABSTRACT
Scientific literacy is an essential skill for understanding scientific information to make informed decisions about science-related issues. The need for scientific literacy has been amplified by the COVID-19 pandemic as citizens encountered scientific information differently than how science is traditionally taught in the classroom. Socioscientific issues (SSI)-based instruction aims to place science in the context of the real-world issues that students encounter and is an approach for all citizens, regardless of if they pursue a science career. The present study explored pre-service teachers' experiences learning with and about SSI and SSI-based instruction as a pedagogical strategy to help increase scientific literacy with future K-12 students. Pre-service teachers participated in an SSI-based unit before choosing an SSI of interest to create a lesson plan. In collaborative groups, pre-service teachers worked to transfer their SSI, nature of science, and content knowledge to the SSI-based lesson plans. Overall, most lesson plans lacked sufficient scientific content, ties to nature of science, and other SSI components. However, pre-service teachers held positive perceptions and attitudes toward SSI and SSI-based instruction. Further exposure to this instructional approach is needed for pre-service teachers to confidently prepare SSI-based lesson plans and units in future classrooms.

Elements and Rationale in Nature of Science for Preservice Teacher Training: Towards Enhanced Instruction

Olalekan Badmus*, University of the Free State, South Africa
Loyiso Jita*, University of the Free State, South Africa

ABSTRACT
This study investigated preservice teachers' knowledge of elements and rationale for Nature of Science (NOS). Literature established gap in pedagogical practices of preservice and novice teachers of science. We examine preservice teachers' knowledge in this aspect of NOS from a quasi-experiment of one-group pretest and post-test design. Instructional intervention over two years along with assignments and presentation with researchers as moderators on the science pedagogy module (History of Science and Philosophy of Science) serves as stimuli over the period. Three research questions and two hypotheses were raised to guide this study. One hundred and thirty-six (112 Life Science and 24 Physical Science) preservice teachers were the participants. Element of NOS (ENOS) and Rationale for NOS (RNOS) were the instruments. Reliability of the instruments yielded Cronbach Alpha values of .83, .91 and .86 across dimensions of clarity, coherence and relevance by fifteen experienced science educators. Data was analysed using t-test and ANCOVA. The study found the intervention to effectively improve the knowledge of elements and rationale for NOS. Better prepared teachers (More Knowledge Order [MKO] have the potential to improved Zone of Proximal Development [ZPD] in learners) by implication have the competence to guide learners for qualitative and effective learning.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Research and Insights on Approaches About Preservice Teachers' Disciplinary Engagement and Instructional Practices
18-Mar-24, 2:00 PM-3:30 PM
Location: Plaza Court 3

Preservice Elementary Teachers' Rationales and Methods for Modifying Opportunities for Student Sensemaking in Science Curricula
Amy Ricketts*, California State University, Long Beach, USA
Korb Michele*, California State University, East Bay, USA

ABSTRACT
In this study, we use the theoretical framework of Pedagogical Design Capacity (PDC, Brown, 2008) to investigate the research question: For what reasons, and in what ways did preservice elementary teachers modify opportunities for student sensemaking as they planned for, implemented and reflected on existing science curricula in their science methods coursework and student teaching? Nineteen participants concurrently enrolled in an elementary science teaching methods course and student teaching each produced fours sets of written data as they analyzed and modified existing lesson plans in terms of opportunities for student sensemaking, then implemented and video recorded those lessons, analyzed those videos in terms of student sensemaking, and proposed revisions for future implementations of the lesson. Across the data set, PSETs made both promising and problematic modifications in terms of opportunities for student sensemaking. Participants' rationales for these modifications reflected ideas about sensemaking as: having real world meaning; being student driven; engaging multiple modalities; leveraging students' funds of

knowledge; both individual and collective processes; connected across a unit; a time consuming process.

Intersections of Sensemaking, Teaching Practices, and Equity and Justice: Comparing Two Elementary Teacher Education Programs

Amber Bismack*, Oakland University, USA
Patricia Bills, Oakland University, USA
Boyun Kim, Oakland University, USA

ABSTRACT

With the increasing diversity of K-12 elementary classrooms, teachers need to know how to equitably engage a diverse array of children in scientific sensemaking. Practice-based teacher education (PBTE) has been found to support novice teachers in learning how to teach science, but minimal research has investigated PBTE that emphasizes equity and justice and how it compares to traditional teacher education (TE). For this reason, we ask, How are high leverage teaching practices (HLP), equity and justice, and teaching for scientific sensemaking represented in a PBTE compared with a traditional TE program? Using a comparative case study approach, we analyzed course documents within two TE programs for how three strands - HLPs, equity and justice, scientific sensemaking - are represented in the two programs. We found that all three strands were more evident in the PBTE program, particularly in the methods courses. Also, the HLPs and scientific sensemaking were evident in the assignments and course schedules of the PBTE courses, but not equity and justice. This could potentially limit preservice teachers' opportunities to learn how to attend to equity and justice issues in education. We discuss implications for teacher education that seeks to prepare equitable and just preservice elementary teachers.

Preservice Teachers' Understanding of Instructional Practice Related to the NGSS SEPs: Impact of the Toolkit

Youngjin Song*, California State University Long Beach, USA
Thao Tran, California State University East Bay, USA
Young Ae Kim*, Defense Language Institute Foreign Language Center, USA
Lisa Martin*, California State University Long Beach, USA
Michele Korb, California State University East Bay, USA

ABSTRACT

The study describes the impact of a large DRK-12 NSF funded project on elementary and secondary preservice teachers' (PSTs) understanding of science instructional practices related to the Next Generation Science Standards (NGSS) Science and Engineering Practices (SEPs). This project has focused on PSTs' understanding and enactment of 3-dimensional science teaching and learning as outlined in NGSS by utilizing a Toolkit—consisting of a Three-Dimensional Mapping Tool (3D Map), a set of Science and Engineering Practice Tools (SEP Tools), and a Phenomenon Tool—to unpack the NGSS. PSTs' understanding and changes of it were measured by a Science Instructional Practices (SIPS) survey instrument. The data were collected from 153 PSTs enrolled in science methods courses on the seven university campuses in the US. The analysis of PSTs' pre- and post-test survey scores showed

that the project Toolkit had a positive effect on the improvement of PSTs' understanding of science instructional practice related to the NGSS SEPs. In particular, PSTs' understanding in eight areas of instructional practice as well as in eight SEPs provided much needed information about how PSTs are currently understanding the NGSS. Also, the Toolkit will be a great asset for science teacher educators in the NARST community.

Supporting Scientific Sensemaking Through NGSS and Disciplinary Language: Case Studies of Preservice Secondary Science Teachers

John Galisky*, UC Santa Barbara, USA
Valerie Meier, UC Santa Barbara, USA
Matthew Bennett, UC Santa Barbara, USA
Julie Bianchini, UC Santa Barbara, USA

ABSTRACT

Given the language-intensive nature of the NGSS, teacher education programs must prepare beginning teachers to support students' learning of science and engineering language. Using the three instructional shifts of asset-oriented science and language learning—making sense of phenomena, engaging in three-dimensional learning, and learning coherently over time through language use—we applied a multiple case study approach to highlight content and language features of preservice teachers' instruction. We investigated which SEPs, CCCs, and language supports were preservice teachers used, and how they were used together to help students engage in sensemaking. We focused on eight participants' edTPA portfolios, selecting two with high scores from each of biology, chemistry, physics, and engineering. Constructing cases, we analyzed all SEPs and CCCs as well as language supports emphasizing multimodality in science education. We found participants employed greater use of sensemaking practices: developing models, constructing explanations, and analyzing data. Common crosscutting concepts related to systems, especially system models and scale. Additionally, participants provided language supports which afforded students opportunities for developing both science concepts and language use. In our discussion, we offer recommendations for ways teacher education programs can better support preservice teachers in teaching both the content and language of science and engineering.

Strand 8: In-service Science Teacher Education
Related Paper Set
Science Teacher Learning with Organizational Contexts
18-Mar-24, 2:00 PM-3:30 PM
Location: Governor's Square 10

(Re)Negotiations and the Relational Politics of Space within a Research-Practice Partnerships

Katherine Ayers*, St. Jude Children's Research Hospital, USA
Robyn Pennella, St. Jude Children's Research Hospital, USA

ABSTRACT
Research-practice partnerships (RPPs) are an effective strategy to enhance science education pedagogy. Yet, researchers note the potential for tensions to arise within RPPs if the goals of teachers and researchers are misaligned, which can result in resistance from teachers in implementing the curriculum. Drawing on Massey's (2005) conceptualization of space as the "the sphere of relations, of contemporaneous multiplicity, and as always under construction", we build upon this research to explore how the relational politics of an RPP change over time to expand or contract kindergarten teachers' implementation of an interdisciplinary learning module in their classroom. We present an analysis of two teachers who, in the most recent iteration of the curriculum, were teaching at the same school, examining how (re)negotiations were made within the social and political contexts of the school environment(s) where these teachers worked to implement the curriculum. We conclude that aspects of the spatial configurations within the RPP create tensions between and among the various players within the space. Namely, district mandates, neighborhood characteristics, and macro-level factors such as a global pandemic work to expand and contract the curriculum's worthwhileness in the kindergarten classroom through the (re)negotiations made at each meeting-up.

Widening Our Lens: Developing Insights From Elementary Science Professional Learning Using an Institutional Frame

Michelle Brown*, The Pennsylvania State University, USA
Carla Zembal-Saul*, The Pennsylvania State University, USA

ABSTRACT
School spaces are intricately situated within institutional factors that influence how teachers take up science sensemaking professional learning (PL) practices. However, organizational frames are underused in PL research. Our study expanded a teacher learning frame with a critical, New Institutional Theory (NIT) frame to understand PL. Using a case study approach, we inductively analyzed how three elementary teachers engaged in a PL model using a teacher learning frame, and then re-analyzed the same data with NIT, expanding our lens to include facilitator interactions. This multifocal analysis expanded our understandings of how teachers engage with PL practices, considering how priorities of English Language Arts (ELA) and language acquisition at the elementary level pulled teachers' attention away from science sensemaking across linguistic repertoires. Our institutional frame allowed us to see how teachers and facilitators pushed against teacher-centered norms unique to the elementary context, and question how histories of "hands-on activities" may have created ambiguities. We found the NIT frame particularly useful when paired with a critical, self-reflexive frame. Implications support the value of multifocal and organizational frames to understand the unique tensions within elementary and emergent multilingual spaces and a need for researchers to try out wider heuristics.

Viewing Science Teacher Learning and Curriculum Enactment Through the Lens of Theory of Practice Architectures

Xavier Fazio*, Brock University, Canada
Stephen Kemmis, Charles Sturt University - Wagga Wagga Campus, Australia

Jessica Zugic, Brock University, Canada

ABSTRACT
Science teachers struggle to implement new curricular ideas from professional development (PD) experiences. These opportunities are crucial for enacting real-world changes to teaching practice, and address global challenges through teaching and learning of socioscientific issues (SSI) in school communities. School situative conditions have become important in how science teachers learn, develop, and enact curricular practices in their classrooms. This poster session contribution will illustrate how researchers frame research using a lens of theory of practice architectures (TPA) to develop a dynamic socio-material understanding of teacher learning within their local school communities. TPA was applied to an ongoing multi-year professional learning study in an elementary school and secondary school. Using a philosophical-empirical approach, observations from PD sessions and collaborative meetings illustrated teachers' practices in the form of sayings, doings, and relatings as they evolved over time concomitantly with changes in school practice architectures. Although specific school conditions, such as timetable restrictions and curriculum accountability, constrained teachers' practices, they were enabled to develop their practices. Overall, TPA was an insightful framework for theorizing changes in science teaching practices at their school sites. Future research focused on PD within schools would benefit from using a TPA approach to theorizing science teacher learning.

Making Sense of Reform Incoherence in a No-Excuses Charter Network
William Lindsay*, University of Colorado Boulder, USA
Valerie Otero, University of Colorado Boulder, USA

ABSTRACT
This cross-case study examines five teachers' year-long efforts to implement practice-based physics instruction within the organizational context of a no-excuses charter network. The teachers were attempting to adapt their didactic "I Do, We Do, You Do" approach to teaching physics to include more opportunities for figuring out disciplinary concepts through evidence and consensus. To assist in these efforts, teachers partnered with a physics education program that provided curricular materials, professional development, and assistance with instructional coaching before and during the 2018-2019 school year. Researchers collected ethnographic field notes and artifacts during professional development workshops, partnership meetings, and bi-weekly lesson observations of case teachers. They also conducted interviews with teachers and students. An organizational sensemaking lens was used to analyze data and informed the production of ethnographic vignettes, case profiles, and cross-case comparisons. Findings included sources of ambiguity and uncertainty experienced by case teachers that were connected to incoherence between the no-excuses context and reform ideals. Certain features of professional development and instructional coaching afforded opportunities for making sense of reform incoherence in a manner aligned with reform goals, while others constrained opportunities. Sensemaking manifested across classrooms through the emergence of hybridized practices that contained components of no-excuses and reform pedagogies.

From Codesign to Co-Adaptation: The Evolution of Professional Learning Across a Long-Term Research Practice Partnership

Quentin Biddy*, University of Colorado Boulder, USA
Jessie Nixon, Weber State University, USA
Srinjita Bhaduri, University of Colorado Boulder, USA
Jennifer Jacobs, University of Colorado Boulder, USA
Mimi Recker, Utah State University, USA
Jeffrey Bush, University of Colorado Boulder, USA

ABSTRACT

Prior research has examined curricular codesign as a key activity structure within Research Practice Partnerships (RPPs) and teacher professional learning (PL). However, little research has focused on how codesign unfolds over the course of a long-term RPP. This paper presents a case study of a six year RPP focused on integrating computational thinking into inquiry-oriented science instruction at the middle school level. We consider how the research and practice partners engaged in ongoing infrastructuring to understand and address emerging contextual needs. Infrastructuring, with attention to barriers and levers, led to design decisions that informed the structure of the PL and its codesign activities. This case study suggests that it is both plausible and reasonable to shift modes of PL over time within an organization, such as from a codesign model of PL to a co-adaptation model. Findings also underscore the importance of considering shifting organizational contexts, engaging in iterative sense-making, and attending to the fit between innovations and existing educational systems. The paper offers insights into the dynamics of codesign, infrastructuring, and PL structures within RPPs, and includes suggestions for future collaborations to promote sustainable and equitable solutions in education.

Organizational Sensemaking During Curriculum Implementation: The Dilemma of Agency, Role of Collaboration, and Discipline-Specific Leadership

Benjamin Lowell*, New York University, USA
Sarah Fogelman, Boston College, USA
Katherine McNeill, Boston College, USA

ABSTRACT

Adopting new instructional materials is an important way to support reform in science education, but implementation can be challenging and complex. Therefore, we conducted a contrasting case study of two middle schools implementing new curricular materials. We conducted semi-structured interviews with teachers and leaders and collected instructional artifacts and reflections from teachers. Using an organizational sensemaking framework, we investigated the tensions that came up during implementation, the resources leveraged to address those tensions, and resulting instructional and leadership practices. One school focused on implementing the materials with fidelity, relying on networking and past practices, which led to a more traditionalized teaching approach. The other school centered the curricular materials, prioritizing understanding the instructional model and customizing for their students, resulting in more aligned instructional practices. Looking across the two cases highlights three key takeaways. First, we discuss the dilemma of agency, which is how

can leaders balance teachers' professional agency with the push for instructional reform, especially when teachers may not fully understand the reform approach. Second, we discuss the role of collaboration as potentially supporting or inhibiting teacher learning. Finally, we highlight the importance of discipline-specific leadership in helping teachers to understand and implement new science instructional materials.

Co-evolution of Teachers' Collective Inquiry and Classroom Practice with Contextual Supports After the Grant Ended

Soo-Yean Shim*, Seoul National University, Republic of Korea
Jessica Thompson, University of Washington, USA

ABSTRACT

This paper explores how contextual supports facilitated the co-evolution of a team of high school teachers' collective inquiry in a professional learning community (PLC) and classroom instruction, focused on supporting students' scientific explanation. Our university research team had supported the PLC through a research-practice partnership project for four years, and in the fifth year, we stepped back and observed how the teachers drove their own collective inquiry and shifted classroom instruction with contextual supports. We qualitatively analyzed the video/audio recordings of the PLC members' interactions in eight 75-minute meetings and a full-day professional development (19 hours) and classroom teaching (34 lessons) for six months. We found that the PLC eventually reached a stage where the entire department actively engaged in rapid cycles of experimenting with a common set of science teaching practices to support students' evidence-based explanation across classrooms and the PLC. It took a few months for the team to get to that stage, and during the few months, the team worked on important groundwork to set goals based on common problems of practice, negotiate expectations about student learning, and discuss instructional practices towards their goals, with the assistance of critical institutional, structural, and historical partnership supports.

Course-Based Teacher Professional Communities (with District and Union Support) at the Center of Three-Dimensional-Science Teaching

Christie Morrison Thomas*, Michigan State University, USA

ABSTRACT

The vision set forth in the National Research Council's (2012) Framework for K-12 Science Education describes students in every science classroom experiencing phenomena-centered instruction. Achieving this requires building local educational systems that change longstanding divisions of responsibility and related identities in ways that support the ongoing teacher learning necessary for achieving the ambitious goals of the NGSS. This comparative study of three similar school districts uses interview data with teachers, district science coordinators, and teachers' union leaders. Two of the study contexts demonstrated traditional divisions of responsibility, which coordinated with teacher social identities as autonomous professionals and social norms for privacy and non-interference. These factors kept professionals' transaction and conflict costs low. Differently, in one study context, teachers' course-based (biology) professional communities were the key organizational level

for selecting and developing common three-dimensional science instructional resources and assessments and using evidence of students' learning to iteratively revise resources and make connections to teachers' classroom instructional practices. The course-based professional community supported coordinated science teacher learning and identity development that aligned with the NGSS. District and union leaders in this context played critical roles in identity leadership and managing and mitigating the transaction and conflict costs inherent in collective decision-making.

"It's Just a Hot Mess": Engaging Teachers' Critical Consciousness in Science Professional Learning

Emily Adah Miller*, University of Georgia, USA
Emily Reigh*, University of California, Santa Cruz, USA
Ayca Fackler*, University of Missouri, USA
Maria Simani*, University of California, Riverside, USA

ABSTRACT

This paper examines teachers' critical consciousness in a PL designed to support the science learning of multilingual learners (MLLs). We compared the critical statements that teachers made in early interviews to those that they made in our PL sessions. In the interviews, we found that teachers drew from their experiential knowledge to offer critical statements about barriers for MLLs at all domains of the organizational system: practice, curriculum, and policy. However, our PL sessions primarily addressed teachers' classroom practice; teachers'' concerns about policy were not taken up or were repositioned to a different domain that was perceived to be within the teacher's locus of control. We discuss the limitations of our approach and describe alternatives that might have supported teachers in taking critical action in the domain of policy. We argue that teachers have valuable organizational knowledge that can be leveraged for change, and that teacher educators and researchers have a responsibility to partner with teachers to address oppression of MLLs at the policy level.

Examining the Affordances of Practical Measures of Science Teacher Learning

Eleanor Anderson, University of Pittsburgh, USA
Jennifer Richards*, Northwestern University, USA

ABSTRACT

The implementation of ambitious teaching frequently requires shifts in how teachers think about and enact content and teacher and student roles. However, opportunities to measure these facets of teacher thinking and practice in ways that allow for ongoing support and adjustments to professional learning are relatively scarce and resource intensive. Working collaboratively with STEM professional learning facilitators in a large urban district, we built on a growing body of research on practical measurement to co-design and pilot practical measures of science teacher learning. Here, we apply a framework developed out of this broader project for the varied organizational functions measures can serve to examine three measures, asking: What are the affordances of each measure for providing meaningful windows into teacher learning? For driving next steps? For functioning as educative

exercises for teachers? Analysis of measure iterations, recordings and artifacts from 27 co-design meetings, and field notes from the measures' use illustrated distinct affordances by measure, as well as some tensions among functions (windows, drivers, exercises) in practice. This study contributes a novel approach to examining science teacher learning through practical measurement with examples and implications for co-design, seeding a generative area for research-practice partnership work.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set
Addressing SocioScientific Issues across Curriculum and Assessments
18-Mar-24, 2:00 PM-3:30 PM
Location: Plaza Court 7

Developing a Measure to Assess Students' Understanding and Reasoning about Issues of Socioscientific Relevance
Eric Schoute*, University of Maryland, USA
Janelle Bailey*, Temple University, USA
Gale Sinatra, University of Southern California, USA
Carla McAuliffe, Institute for Global Environmental Strategies, USA

ABSTRACT
Students' reasoning about socioscientific issues may be motivated by accuracy (i.e., wanting to be correct in an explanation) or by a desired conclusion (i.e., wanting to support their existing belief). We have developed the Reasoning About Socioscientific Issues (RASSI) measure, a three-tier instrument to gauge students' knowledge, reasoning, and confidence in that reasoning around topics such as the causes of climate change, impact of climate change on extreme weather events, and the availability of freshwater resources. Items were developed to correspond to science topics of social relevance aligned with the Next Generation Science Standards by researchers with backgrounds in educational sciences and Earth sciences, and reviewed by team members with similar backgrounds and significant classroom teaching experience. Initial testing of the instrument with middle and high school students and preservice science teachers shows good distributions of responses across all three types of questions, and further reveals that there is room for growth in students' knowledge and reasoning about socioscientific issues. We provide a specific example from the RASSI to demonstrate its wording and students' responses. This instrument may be particularly useful when used in conjunction with lessons that focus on evaluating competing scientific explanations.

Curriculum Design and Improvement: Integrating AI Concepts and Societal Problems in a Secondary Science Module
Yue Bai*, University of Connecticut, USA
Todd Campbell*, University of Connecticut, USA
Sybille Legitime, University of Connecticut, USA
Derek Aguiar, University of Connecticut, USA

Megan Staples, University of Connecticut, USA
Jacqueline Corricelli, West Hatford Public Schools, USA

ABSTRACT
While researchers and educators have endeavored to explore ways to introduce data science and artificial intelligence (DS&AI) concepts into K-12 education, accessibility to such courses is unequal among urban schools. To address this disparity and harness the reciprocal advantages for integrating computer science concepts into science lessons, we aimed to support high school science teachers in guiding students to apply science ideas and DS&AI technology to address social problems in science lessons. In this way, more students will be able to have access to DS&AI and related computer science concepts, as well as use those concepts as additional tools for engaging in science learning that seeks social transformation to address current and future challenges. In this presentation, we will share a planning tool for an integrating DS&AI science module and two lessons we designed using the template. We will also illustrate how we piloted and refined one of the lessons, including assessment of the lesson using data collected from student artifacts. Subsequent modifications we made and the effects observed from re-implementation of the lesson after refinement will be presented as well.

Structuring Educative Curriculum Materials in an Issues-Based Unit

Rebecca Lesnefsky*, University of North Carolina, USA
Troy Sadler, University of North Carolina, USA
Zhen Xu, University of North Carolina, USA
David Fortus, Weizmann Institute of Science, Israel

ABSTRACT
The Grand Challenges curriculum puts together two longstanding calls in science education: a) integrating practices and content and b) centering important socio-scientific issues in student learning. To support teachers in answering the demanding instructional and pedagogical shifts, our curriculum aims to support teachers through educative curriculum materials. In doing so, the curriculum design team had to wrestle with how to effectively package and present educative features. Drawing from published literature and the experience of the team, the design team considered 1) how to provide adequate, accessible, and usable support for a variety of teachers without making the materials too cumbersome? 2) how should our educative features support teachers in planning and meaningfully modifying the curriculum for their local contexts? And 3) how can ECM support teachers in integrating science practices and content in a real-world context? We addressed a landscape of decision points to add to the limited research on how ECM can support teachers and strengthen the field's understanding of effective support and curriculum design for student and teacher learning.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set
Middle School: Curriculum Impact on Student Learning and Engagement
18-Mar-24, 2:00 PM-3:30 PM
Location: Plaza Court 6

Developing a Three-Dimensional Learning Progression for Properties and Structure of Matter at Middle School Level

Mingchun Huang*, Michigan State University CREATE for STEM Institute, USA
Peng He, Michigan State University CREATE for STEM Institute, USA
Mao-Ren Zeng, Michigan State University CREATE for STEM Institute, USA
Namsoo Shin, Michigan State University CREATE for STEM Institute, USA
Jonathan Bowers, Michigan State University, USA
Joseph Krajcik, Michigan State University CREATE for STEM Institute, USA

ABSTRACT
This study aims to develop an NGSS-aligned three-dimensional learning progression (3DLP) at middle school level, incorporating Properties and Structure of Matter (PSM), Constructing Scientific Explanations (CSE), and Cause and Effect (C&E). According to a principled design approach, we articulated an initial 3DLP by identifying and unpacking NGSS performance expectations, constructing separate levels, creating an integrated dimension map of three-dimensional performances, and articulating initial 3DLP levels and pathways. To verify the levels in the initial 3DLP, we conducted three experts' feedback on separated levels of the three dimensions and collected four students' cognitive interview data from a public school to support the integrated 3DLP levels. Using the directed content analysis, we found that students could achieve the highest levels in PSM and CSE but remain at Level 3 on C&E. The observed patterns support our assumption that high levels of PSM are matching with high CSE and C&E to articulate the 3DLP levels. This study contributes to the teaching and learning of science and the NARST community by presenting a design process for developing a 3DLP aligned with the NGSS, which provides potential guidelines for teachers' adaptations of their curriculum and assessment materials and instructional practices in classrooms.

Collect, Analyze Interpret, Oh My! 7th grade students' Intended Engagements in the OpenSciEd Curriculum

Amanda Garner*, University of Tennessee, USA
Hanhui Bao*, University of Tennessee, USA
Joshua Rosenberg, University of Tennessee, USA

ABSTRACT
Next Generation Science Standards (NGSS; NGSS Lead States, 2013) identifies deriving meaning from scientific data as an important skill to master in reference to working with data. Even though Analyzing and interpreting data has been listed as one of the practices in the Science and Engineering Practices (SEP) in the NGSS, there is insufficient research

investigating this subject compared to other SEPs. In order to identify how students are working with data within a science curriculum, we carried out an analysis of two units of 7th-grade science curriculum from the Open SciEd. Open SciEd offers opportunities for students to work with data sets within its units and provides opportunities for students to participate in the full data cycle. However, they mostly work with small data sets and very specific data visualization types. Students have many opportunities to engage with ready-to-use data, which allows them to have stronger data analysis and interpretation skills. Even though there are diverse types of data, there are no opportunities for students to create data visualization beyond tables and charts within the two units we analyzed.

Fostering Quantum Understanding: Crafting, Applying, and Assessing A Science Curriculum for Middle School

Zeynep Akdemir*, Purdue University, USA
Nicholas Dang, Purdue University, USA
Muhsin Menekse, Purdue University, USA

ABSTRACT
Quantum technology is becoming important in various advanced industries and academic fields like materials science, AI, and cryptography. To help students understand quantum physics better and advance quantum technologies, we made a special curriculum for middle schoolers. This curriculum focuses on hands-on learning and was tested with 873 middle school students in the Midwest. The results showed that students learned quantum concepts better with this curriculum. Our study contributes to better ways of teaching quantum ideas in K-12 schools. This approach is also unique in that it does not heavily focus on math and helps create the next generation of quantum tech enthusiasts and innovators.

Middle School Space Science Education: An Investigation of Self-Efficacy, Content Knowledge, and STEM Career Interests

Kristina Otero*, University of Central Florida, USA
Glenda Gunter, University of Central Florida, USA
Debbie Hahs-Vaughn, University of Central Florida, USA

ABSTRACT
The USA is at risk of losing its position as a global leader in the space sector because students are performing below other space faring nations on international science assessments and are showing declining interest in science, technology, engineering, and mathematics (STEM) careers. Research on student self-efficacy in science has shown positive relationships with student academic achievement and STEM career interest. In this study, the extent to which participation in space science enrichment activities affected middle school students' space science self-efficacy, content knowledge, and interest in pursuing a STEM career was examined. The enrichment activities included 20 curated space science lessons and the Aldrin Family Foundation's Giant Moon MapTM. Pre- and post-survey data were collected using quantitative measurement scales that assessed the variables of interest. Multilevel modeling was used for data analysis of pre- and post-surveys of students (n=397 pre, n=244 post). Results of the multilevel models amongst clusters of students indicated no statistically

significant relationships of the variables of interest. Findings were limited by missing student data, lack of comparison group post-survey participation, and underuse of the enrichment activities.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set
Considering Black and Latinx/é Experiences in Engineering and Science Learning Environments for Justice & Equity
18-Mar-24, 2:00 PM-3:30 PM
Location: Governor's Square 14

The Impact of Racialized Ideologies on Latino/a/x/é Engineering Students at Emerging HSIs
Joel Mejia*, The University of Texas at San Antonio, USA

ABSTRACT
Although more Latinos/as/xs are attending college, they continue to face many barriers that preclude them from achieving degrees in engineering, including the high poverty rates, first-generation status, part-time enrollment status, and remedial placement. While these factors are known, there is one particular issue that is rarely part of the conversation in the broadening participation efforts in engineering education: the role that racialized ideologies has played in providing access and equitable engineering education. This paper focuses on the testimonios collected from 12 undergraduate sophomore and junior self-identified Latino/a/x and Mexican American engineering students currently enrolled at three emerging Hispanic Serving Institutions (HSIs) in the Southwest U.S. The testimonios indicate that racialized experiences in engineering are a result of arrebatos created as a result of the vestiges of coloniality, including language delegitimization, deficit thinking and framing, and identity erasure in engineering spaces. The research explores how Latino/a/x engineering students recognize the sociopolitical realities that led to these circumstances. The research serves as a call for policy changes at emerging HSIs and their engineering programs where Latinos/as/xs are often perceived as the prohibited inhabitants of engineering spaces.

Justice-oriented Engineering Design: Latinx/é/a/o Students Finding Inspiration in their Community Resources
Greses Pérez*, Tufts University, USA
Ymbar Polanco Pino, Tufts University, USA
Clara Mabour, Tufts University, USA
G.R. Marvez, Tufts University, USA

ABSTRACT
Engineering is tasked with developing solutions for a diverse population. To rise to this challenge, we need engineers that reflect the communities they serve and their education needs to be explicit about incorporating the perspectives of people. However, it is not yet well understood how exactly this learning process of developing connections between

communities and engineering works. This study focuses on the role of language practices and cultural understandings on how students define socially-oriented engineering design problems, with attention to media and audience. Through this work, we imagine educational possibilities where learning environments are driven by the resources of minoritized communities and expand the learning opportunities for students to become informed citizens who make decisions about socio-scientific issues, from climate change to biases in medicine. It dismantles racial injustices through diverse educators and media that regard the practices of communities as valuable for engineering learning, thus expanding conceptions of the discipline. The outcomes are poised to combat the elements in the environment that pressure minoritized groups to assimilate because their realities are rarely legitimized in science and engineering education.

Building Meaningful Education with Engineering to Foster Care and Relationality

Brian Gravel*, Tufts University, USA
Eli Tucker-Raymond*, Boston University, USA
Cara Hovhenessian*, Malden Public Schools, USA
Chris Fitzpatrick*, Malden Public Schools, USA
Amon Millner, Olin College of Engineering, USA
Maria Olivares, Boston University, USA

ABSTRACT

We describe engineering as pivotal in creating justice-oriented and equitable learning environments, as it weaves together peoples, materials, and relationships. We present an asset-based learning design that blends design, making, and relationality in supporting Black, Latinx and Southeast Asian learners and their teachers to center care and equity through engineering learning. We integrate descriptions of engineering practice with artistic practice, making, and explicit consideration of care and equity as the basis for an educational design. The racially and linguistically diverse group of teachers and students coalesced in designing for an issue in young people's lives: they want to spend time in the city parks, exercising with friends and building relationships, yet they do not have equitable access to sports equipment. They designed "Parq-u-Play," a locker-style installation that allows visitors to borrow sports equipment in parks for free. Through this work, new relational structures were built among students and teachers, and new relationships to STEM disciplinary practice were forged through computational making, which closely resembles engineering described through justice-oriented frameworks. We elaborate on this case, using vignettes that center conversations around care, equity, and relationality within the engineering design work the teams of learners engaged.

"Not in this Class:" Examining Space, Power, & Identity in the Context of HS Engineering

Christopher Wright*, Drexel University, USA
George Schafer, Drexel University, USA
Monet Harbison, Drexel University, USA
Sinead Meehan, Drexel University, USA
Tajma Cameron, Drexel University, USA

ABSTRACT
Looking to explore and understand learning and identity in a secondary engineering classroom, this study examined how a Black adolescent interpreted place within the intersections of space, power, and identity. Situated in a secondary STEM school that served a predominantly Black and Brown student population, this case study explored Royal's development of engineering competencies and identities. Building on frameworks of situated learning, identity theory, and resource pedagogies, a practice-linked identities framework guided data collection and analysis processes. Analysis revealed that Royal's interpretation of being able to engage in meaningful engineering practices and being recognized as a good engineering student varied across contexts of home, out-of-school programming, and his high school engineering class. Findings from this study contribute to the argument that the engineering education community needs to increase its emphasis and attention on the design of just and equitable learning spaces that make an array of disciplinary identities available to students.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Language in Science Education: Examining Translanguaging and Unsettling Raciolinguistic Hierarchies
18-Mar-24, 2:00 PM-3:30 PM
Location: Governor's Square 12

Equity for Whom? Examining Multilingual Learners' Language Practices Across Asset-Oriented Science and Engineering Education Research
Karina Méndez Pérez*, University of Texas at Austin, USA
María González-Howard, University of Texas at Austin, USA
Sage Andersen, University of Texas at Austin, USA

ABSTRACT
Authors of current reform documents and standards posit a vision of science and engineering education that centers learners' sensemaking repertoires to co-construct meaning of the natural and designed world. Learners engage in language-rich disciplinary practices that require them to use language in complex ways to make their sensemaking visible to themselves and others. For multilingual learners, it is important to consider the different language practices they draw upon to support their science and engineering learning. Although this vision provides multilingual learners with opportunities to engage in meaningful science and engineering instruction, critical scholars have pointed out that the vision of equity represented by current reform documents and standards focuses on providing access to disciplinary language practices and expressed the need to move towards ideas of equity as transformation that values all multilingual learners' language practices when communicating their ideas and constructing knowledge. In this systematic literature review, we use a disciplinary perspective of translanguaging to understand how researchers conceptualize multilingual learners' language practices within asset-oriented pedagogies. We found that language practices were conceptualized across the selected in two ways: as

access to disciplinary practices to communicate ideas and as transformative for expanding what counts as language in science and engineering.

Interactions in a Multilingual Science Classroom in Lebanon

Christelle Fayad*, Texas Christian University, USA
Hayat Hokayem*, Texas Christian University, USA

ABSTRACT

Language is an additional barrier for students' science learning in multilingual classrooms. Most Lebanese students learn science in a language different from their Arabic native language. To understand the complexities of this situation, we investigated a fifth-grade classroom in Beirut, Lebanon where the students were learning about the life cycles. We videotaped classrooms over a period of six weeks, and transcribed the videos verbatim. We then analyzed how the students used "translanguaging" in various cognitive situations, how the teacher's use of language varied with various students' interactions, and how the teacher's follow up to students' responses were. We found that while students used their home language, Arabic, when faced with high cognitive demand, the teacher used English predominantly in explanations and when providing feedback to students who responded in Arabic. However, the teacher still fostered students' conceptual understanding by scaffolding strategies that we discuss.

A Qualitative Look at Raciolinguistic Ideologies Among Preservice Science and Math Teachers

Maricela Leon, Southern Methodist University, USA
Quentin Sedlacek*, Southern Methodist University, USA
Catherine Lemmi, California State University Chico, USA
Kimberly Feldman, University of Maryland Baltimore County, USA

ABSTRACT

Raciolinguistic ideologies can (re)produce racial inequity in science and mathematics education. Fortunately, a growing number of teacher education programs are working to help teachers disrupt these inequities and and build science and mathematics classrooms that welcome students' full linguistic repertoires. The authors sought to understand the impact of these efforts through a qualitative analysis of 14 interviews with preservice teachers of science and mathematics. The authors found tentative evidence of shifts toward more language-inclusive ideology among some teachers but not others, and find that specific strategies such as disaggregate instruction may help facilitate such shifts. Implications for science and mathematics teacher education are discussed.

Raciolinguistic Hierarchies of U.S. Science Education: Why Hindsight Matters for Translanguaging Today

Kathryn Kirchgasler*, University of Wisconsin–Madison, USA
Diego Román*, University of Wisconsin–Madison, USA

ABSTRACT
Science education scholars have raised concerns about depoliticized, instrumentalized uptakes of translanguaging, such as positing students' linguistic repertoires as a steppingstone toward 'normality' versus challenging monolingual, monoglossic norms. Our study seeks to denaturalize how U.S. science education historically defined some language(s), registers, and varieties as more scientific than others. We investigate how early 20th-century U.S. science education began separating languages (and speakers) along hierarchies of value and what changed with the mid-century rise of bilingual education. Following methods of raciolinguistic genealogy, the study analyzes a wide range of archival sources (e.g., research journals, teachers' guides, policy reports, curricula), including segregated and colonial science instruction and a mid-century reform encouraging flexible use of students' dynamic multilingual practices. Analytically, we borrow the heuristic of language orientations to examine how U.S. science education adopted principles and practices making students' language(s) appear as a problem, right, or resource. The analysis suggests that, for over a century, the field has projected—and contested—entangled hierarchies of named languages, abstract/applied language, and populations racialized as already/not-yet scientific. Our discussion echoes prior concerns, offers new cautions, and opens further deliberation over roles translanguaging might play in dismantling the field's enduring raciolinguistic hierarchies.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set
Use Technology in Science Education Research
18-Mar-24, 2:00 PM-3:30 PM
Location: Governor's Square 15

Integrating Artificial Intelligence-Based Methods Into Qualitative Science Education Research – a Case for Computational Grounded Theory
Paul Tschisgale*, Leibniz Institute for Science and Mathematics Education, Germany
Peter Wulff, Heidelberg University of Education, Germany
Marcus Kubsch, Freie Universität Berlin, Germany

ABSTRACT
Qualitative methods have provided key insights in science education research, however, they face challenges: As such methods require a series of judgments by the analysts, they are difficult to validate and reproduce. Further, they are hard to scale, i.e., they are unavailable for analyzing large-scale data. Reacting to these challenges and leveraging the potential of emerging artificial intelligence (AI) methods such as natural language processing (NLP) and machine learning (ML), Laura Nelson has proposed the concept of Computational Grounded Theory (CGT). CGT aims at integrating AI into qualitative researchers' workflows and proceeds in three steps: In the first step, one leverages the power of NLP and unsupervised ML for pattern detection. In the second step, one relies on the integrative and interpretative capabilities of human analysts to add quality and depth to the quantity and breadth of the first step. In the last step, one uses supervised ML to test the extent to which the detected

and refined patterns in the first two steps hold throughout the whole dataset. In this study, we apply CGT to investigate physics problem solving approaches of N = 417 students based on textual data and discuss its potentials and challenges for science education research.

An Examination of the Use of Large Language Models to Aid Analysis of Textual Data

Robert Tai*, University of Virginia, USA
Lillian Bentley*, University of Virginia, USA
Xin Xia*, University of Virginia, USA
Jason Sitt, University of Virginia, USA
Sarah Fankhauser*, Oxford College of Emory University, USA
Ana Chicas-Mosier, University of Kansas, USA
Barnas Monteith, THInc AI Group, USA

ABSTRACT

The increasing use of machine learning and Large Language Models (LLMs) opens up opportunities to use these artificially intelligent algorithms in novel ways. In this article, we propose a methodology using LLMs to support traditional deductive coding in qualitative research. We began our analysis with three different sample texts taken from existing interviews. Next, we created a codebook and inputted the sample text and codebook into an LLM. We asked the LLM to determine if the codes were present in a sample text provided and requested evidence to support the coding. The sample texts were inputted 160 times to record changes between iterations of the LLM response. Each iteration was analogous to a new coder deductively analyzing the given text with the codebook information. In our results, we present the outputs for these recursive analyses, along with a comparison of the LLM coding to evaluations made by human coders using traditional coding methods. We argue that LLM analysis can aid qualitative researchers by deductively coding transcripts, providing a systematic and reliable platform for code identification, and offering a means of avoiding analysis misalignment. Implications of using LLM in research practice are discussed, along with current limitations.

Exploring Real-Time Engagement in Data Practices: Insights from Learning Analytics in Secondary Science Investigations

Britt Miller*, George Mason University, USA
Erin Peters-Burton*, George Mason University, USA

ABSTRACT

This study addresses the challenge of observing and evaluating student engagement in data practices during science investigations in real-time. By leveraging learning analytics from the Science Practices Innovation Notebook, an online platform with computational supports, this mixed methods study examines how high school students interact with data practices and regulate their own learning within science investigations. Initial findings indicate that students often require support during the data practice "Create" when they must generate their own data from a tool or observation. A detailed case study further reveals students' iterative engagement across data practices, emphasizing the need for a more comprehensive understanding of the data cycle. The study contributes insights into the role

of learning analytics in science education research, specifically around data practices, suggesting ways to personalize learning, inform pedagogy, and create more inclusive learning experiences and resources, ultimately enhancing science instruction and education across diverse learning contexts.

Use of Neurocognitive Data to Evaluate Text Summarization of Science Content

Richard Lamb*, East Carolina University, USA
Zachary Pugh, North Carolina State University, USA
Amal Hashky, University of Florida, USA
Surbhi Rathore, University of Rhode Island, USA
Wenyuan Wang, University of North Carolina Chapel Hill, USA
K Kosiur, Department of Defense, USA
Mamoun Margini, University of Florida, USA

ABSTRACT
With the dramatic increase in textual information available via the Internet and other sources, students in science students are continually overwhelmed with the amount of data and information available to them. As information availability continues to expand exponentially, students' educators are seeking more effective ways to summarize text and, more importantly, evaluate text summaries. The purpose of this study is to determine the feasibility of assessing text summary quality by means of neurological measures of cognitive demand obtained during readings of those summaries. Thirty-six participants were selected from a pool of 100 high school science students. Results suggest that significant detectable differences in cognitive demand manifest when reading human-summarized text when compared to computer-summarized text. Second, levels of cognitive demand seem to align with participants' preferences. Measures of cognitive demand in assessment of text summarization quality have several advantages over existing approaches, a key one being that such measures tap autonomic nervous system responses not under conscious control, allowing for more objective evaluation of text difficulty.

Strand 15: Policy, Reform, and Program Evaluation
SC-Organized Paper Set
Exploring the Role and Views of Varied Stakeholders in Science Teaching and Learning
18-Mar-24, 2:00 PM-3:30 PM
Location: Directors Row I

Examining the Alignment of Elementary Science Specialist and Principal Beliefs about Teaching and Learning Science

Melissa Pearcy*, Washington State University, USA
Danielle Malone*, Washington State University, USA
Rachel Larson*, Washington State University, USA

ABSTRACT
This study examines the alignment of beliefs between Elementary Science Specialists (ESS) and principals concerning science instruction and the ESS model. While research has examined the effectiveness of the ESS model, little emphasis has been placed on exploring the beliefs of ESSs and principals. The study adopts a constructivist paradigm and utilizes a qualitative comparative case study methodology to capture the alignment of beliefs between the two key stakeholders. Interviews with both principals and their corresponding ESS were examined in this study. Three main themes of beliefs emerged: about science and knowledge, science instruction, and the ESS model. The findings reveal cases where principals and ESSs share a unified vision of science education, highlighting its value for all students. Moreover, aligning beliefs in science instruction emphasizes engaging students in sensemaking activities and fostering diverse and inclusive learning environments. Finally, cases highlight the impact of the ESS model on forming relationships between students and teachers, leading to a nurturing learning environment where students thrive in their scientific pursuits. The study's insights offer valuable implications for policymakers, teacher educators, and professional developers, aiming to inform decisions about science instruction models and effective implementation of the ESS model in elementary science education.

'I'm Just a Parapro': The Role of Science Paraprofessionals when Elementary Science is Undervalued
Stefanie Marshall*, Michigan State University, USA

ABSTRACT
School leaders are instrumental in creating the context necessary to support elementary science instruction (NASEM, 2021). Key decisions concerning time, resources spent, professional development allocated towards specific content, and maintenance of policies are often based on decisions made by and with the school principal, holding principals primarily responsible for instructional decisions (Spillane & Hunt, 2010). However, it is often the case that science leaders are not necessarily in formal leadership positions in elementary schools, making elementary science instruction precarious and even sometimes neglected compared to content areas like reading/ELA and mathematics (Author, 2021). This study explores the role of power and the decision-making opportunities of science paraprofessionals in one district who offered instructional support with the supervision of a certified teacher (Author, 2023). This study examines the roles and responsibilities of an elementary science paraprofessional in one district and the distribution of leadership. Initial findings indicate that science paraprofessionals are to fulfill their responsibilities if it is prioritized within a school. Science paraprofessionals also expressed their limited authority and power to make decisions, even when they are identified as science decision-makers by administrators.

Understanding Parents' Perspectives on Climate Change Education
Lauren Madden*, The College of New Jersey, USA
Arti Joshi, The College of New Jersey, USA
Margaret Wang, SubjecttoClimate, USA
Julia Turner, SubjecttoClimate, USA

ABSTRACT
As climate change education becomes more prevalent in schools around the globe, it becomes increasingly important to understand parents' perspectives on this topic. Children cross boundaries between home and school culture each day, and parents' attitudes, beliefs, and practices can influence children's academic engagement in all content areas. In the 2022–23 academic year, New Jersey (NJ) enacted climate change education standards across grade levels and subject areas. We seek to understand parents' perspectives on this change in curriculum. In October–November 2022, a survey was distributed to parents of children attending public school in NJ to identify the way in which parents discuss, support, and question their children's education about climate change. Eighty-three parents responded to the survey. Findings suggest that parents talk about climate change with their children at home using a variety of tools and strategies to support these discussions. However, parents are concerned about their childrens' teachers' preparedness to introduce climate change appropriately and their own readiness to support this instruction at home. A few of the parent respondents also expressed concern about learning ways to talk about climate change in a manner that is mindful of children's developmental and mental health needs.

State Board of Education Expertise in the Development of High School Science Standards
Allison Esparza*, Texas A&M University, USA
Joanne Olson*, Texas A&M University, USA

ABSTRACT
This study investigated the science standard development process in Texas policy-making. We analyzed a State Board of Education meeting through naturalistic inquiry to determine board members' science education expertise to develop high school science standards. The study results indicate that several motions raised concerns regarding content expertise and/or the revision process. Additionally, not all of Schwab's Commonplaces are equally represented during the science standard review and revision process. To ensure the successful development of accurate and developmentally appropriate science standards that enable in-depth learning, it is necessary to have equal representation of the subject matter, the learner, the teacher, and the milieu.

Publications Advisory Committee Sponsored Session
Publishing, Reviewing, and Writing for JRST
18-Mar-24, 3:45 PM-5:15 PM
Location: Governor's Square 11

Publishing, Reviewing, and Writing for JRST

ORGANIZERS
Felicia Mensah, Columbia University, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA

ABSTRACT
The Journal of Research in Science Teaching (JRST) is the official journal of NARST: A global organization for improving science education through research. JRST is the premier journal in the field with the largest impact factor. Its reputation relies on our associate editors, reviewers, and authors to promote compelling research consistent with the highest standards of varied theoretical traditions. In this session, the editors, Dr. Troy Sadler and Dr. Felicia Moore Mensah will present an overview of important factors in writing and reviewing for JRST. They will explain the processes JRST uses to facilitate peer review and make publication decisions, and provide some examples for discussions. This will be an interactive session in which participants are encouraged to ask questions about the journal and its processes and share ideas for improving JRST. Drs. Sadler and Mensah will provide updates on how they are realizing their vision for JRST through new initiatives, and discuss ways that the NARST community may work together for improving the journal and its outreach and support.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
Nature-based, Community-based, and Inquiry-based Practices
18-Mar-24, 3:45 PM-5:15 PM
Location: Directors Row H

"Science Doesn't Have to Be Scary": The Accessibility of Doing Nature-Based Science
Steph Dean*, Clemson University, USA
Andrew Gilbert, George Mason University, USA
Jim Lane*, Mahtomedi High School, USA
Paul Bocko, Antioch University, USA

ABSTRACT
It is important that young people are scientifically literate and prepared to address the challenges facing humanity on a global scale. Nature-based science poses one promising possibility that emphasizes the accessibility of science within a K-12 setting. This empirical study examined the experiences of both teachers and students involved in outdoor environmental education (OEE) and the ways in which this learning approach supports students as scientists. Using a narrative inquiry framework, we interviewed eleven teachers and former students, collecting their stories to understand how the structure of OEE learning corresponds to the accessibility of science. Each interview transcript was individually open coded by the research team before being unified into one thematic map. Three key themes surfaced from the data, highlighting the ways in which OEE teachers approach science instruction: (1) fostering authentic wonder-based investigations, (2) elevating play, and (3) creating time and space for slow observations. These findings have important implications for the field as it relates to the accessibility of science learning and the ways in which we can cultivate a positive interest towards science. The work will have a broad appeal to those interested in connecting science to OEE as well as to those working with teachers.

Does a Nature-Based Preschool Curriculum Address NGSS Science & Engineering Disciplines and Practices? a Case Study

Jennifer Gallo-Fox*, University of Delaware, USA
Ariadni Kouzeli, University of Delaware, USA

ABSTRACT

Nature-based education programs focus on much of their curriculum in the local place-based environment. Limited research has examined the area of science and engineering learning opportunities in nature-based classrooms. This case study investigated a nature preschool teacher's family communications about curriculum and program activities in order to comprehend the extent NGSS practices and disciplinary areas were addressed in an emergent child-centered curriculum over two years. The preschool curriculum was nature oriented, child-centered and emergent. Children engaged in STEM activities throughout the day. Data sources cross over two years and are comprised of the teacher's classroom communications to families: weekly emails, lesson plan/activity grids and class posts. Findings show that children were involved in life science and science practices most frequently, but addressed all STEM disciplines and science and engineering practices regularly throughout the year. This paper describes the NGSS content that was addressed and includes examples and photographs of the children's learning experiences.

The Hidden Work: A Collaborative Self-Study Approach to Planning Projects for Community-Based Informal STEM Program

Ti'Era Worsley*, The University of North Carolina at Greensboro, USA
Matthew Fisher, The University of North Carolina at Greensboro, USA

ABSTRACT

The design of informal STEM programs for youth to learn and create often focuses on leading students toward a successful end product. However, less is known about the design choices of how these programs are developed and implemented. Informal STEM educators are consistently working to redesign learning opportunities in non-traditional ways that motivate youth to engage in STEM through personal connections to the content. This proposal asks the question, in what ways does critical relationality support informal STEM educators' decision-making process toward creating learning opportunities within community-based STEM programs? This study is situated in a community-based informal STEM program at a local Boys and Girls Club as the created two large-scale projects. We frame our study in critical relationality as it highlights relational equity within learning environments which in turn creates and reimagines opportunities for youth of color to engage in STEM. We sought to understand the role of critical relationality in the decision-making process of informal STEM educators that created learning opportunities for youth. By reflecting on our decisions three elements surfaced; simpler methods were not always as impactful, youth needed to have a testimony of success, and youth appreciation of being informed.

Learning Coherence in Inquiry: Supporting Pre-Service Teachers with Inquiry-Based Investigations Tool

Ibrahim Delen*, Usak University, Turkey
Salih Uzun, Usak University, Turkey

ABSTRACT

Inquiry focuses on the techniques and activities used by the teacher to aid pupils in the acquisition of scientific ideas. Scientific inquiry involves carrying out an abstract operation, evaluating a variable's worth, dependability, and importance, identifying similarities or differences between two or more variables, providing the outcome that results from a stated condition, and providing proof or justification for why something occurred. Thus, the support provided in this process is crucial to kicking off these ideas. The goal of this study was to examine how a new inquiry-based investigations tool could be implemented in a teacher education program. We worked with pre-service teachers (PSTs) studying science education at a public university in Tu_rkiye. The study group was in their 3rd year in the degree program (juniors). Prior to the science laboratory course, PSTs mainly took content-level courses. Inquiry-based investigations tool was designed in a collaboration project that involved five different European countries. The tool is designed to support inquiry as a cycle. The use of the tool in different experiments aided PSTs in understanding experiment setup and use of data. However, PSTs' quality of arguments was connected to the content understanding.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

SC-Organized Paper Set

Physical Science Teaching and Learning

18-Mar-24, 3:45 PM-5:15 PM

Location: Governor's Square 17

Student, Teacher, and School-Level Predictors of AP Chemistry Performance in U.S. High Schools

Martin Palermo, Stony Brook University, USA
Robert Krakehl, Stony Brook University, USA
Angela Kelly*, Stony Brook University, USA

ABSTRACT

Advanced Placement (AP) science participation and performance have been identified as predictors of high school achievement; post-secondary academic performance; science, technology, engineering, and mathematics (STEM) persistence; and degree completion. This study examined student, teacher, and school-level predictors of AP Chemistry performance among a sample of 148 teachers and 2,991 students in New York State. The theoretical framework is derived from theories suggesting that teacher variables including preparation and experience, as well as school-level contextual variables including curricular offerings and demographics, are predictive of student performance. A multiple linear regression model demonstrated that the percentages of test-takers who were women, underrepresented

minorities in STEM, and economically disadvantaged were negative predictors of AP Chemistry performance. Chemistry teacher characteristics including certification, years of experience, gender, and course load in chemistry were not significant predictors of student performance. Additionally, AP Chemistry enrollments and access to to other AP science courses within the school districts did not significantly predict student performance. These results suggest that demographic characteristics largely predict performance, and teacher preparation does not influence students' outcomes. Consequently, current teacher preparation programs may not adequately prepare teachers to work in low income schools and to promote more equitable AP Chemistry outcomes.

9th Grade Students' Knowledge and Self-Efficacy When Learning to Explain Energy Changes in Chemical Reactions.

Nabeh Alatawna*, Ben-Gurion University, Israel
Elon langbeheim*, Ben-Gurion University, Israel

ABSTRACT

We examined an inquiry-based unit that introduced chemical bonding and energy changes in chemical reactions to 9th grade students from disadvantaged, low income background. The unit includes empirical investigations of energy change in various processes, and then introduces its micro-level explanations, that are based on breaking and forming chemical bonds. The empirical part involves measuring the change in temperature of reactions, and the theoretical, explanatory part uses learning scaffolds such as analogies, and computer simulations.

Since self-efficacy is an important aspect of students' motivation - especially among disadvantaged ones - we examined how this approach affected students' conceptual understanding, and their self-efficacy. Two 9th grade classrooms – one from a regular school and another from a science magnet school, participated in the study. The same teacher taught the unit in both classrooms. The results show that the magnet school students had better initial knowledge of energy change, and had larger learning gains in the explanatory section of the learning unit (that focuses on chemical bonding). In addition, students' self-efficacy - significantly increased in both schools. These findings imply that learning about energy changes, by measuring change in temperature, boosts understanding and increases the self-efficacy among both highly motivated students and regular students.

Drawing Meaning from Student-Generated Drawings: Characterising Chemistry Teachers' Noticing

Hanna Stammes*, Radboud University, Netherlands
Lesley de Putter, Eindhoven University of Technology, Netherlands

ABSTRACT

This study illuminates how chemistry teachers may draw meaning from student-generated drawings. Student-generated drawings can offer a unique window into students' developing thinking, but teacher noticing regarding drawings was not yet examined. This study explored noticing from two dimensions: recognition of drawing features, and adoption of analytic stances. We gathered and analysed data on experienced teachers' in-the-moment (amidst active classroom) and delayed noticing (with time to review student drawings) within teachers' own classroom contexts. Findings show that teacher noticing involved recognising drawing features in four categories. These were visual forms (incl. icons and chemical symbols), quantities (depictions of amounts and distances/sizes), scale (incl. depictions of entities at mesoscopic, molecular-atomic and electronic length scales), and properties and behaviours (incl. composition, structure and electrical aspects). We furthermore found teachers to use all three stances (i.e. descriptive, evaluative, sense making) but in different frequencies. The study's results point to drawing-specific characteristics of teacher noticing, and yield suggestions for (novice) teachers and teacher educators to help broaden teachers' scope of what can be meaningful to look for in student drawings. The study furthermore adds to the relatively small body of literature examining science teachers' noticing in real school contexts.

Teaching Particle Physics to Promote Critical Thinking
Farahnaz Sadidi*, Technische Universität Dresden, Germany
Gesche Pospiech, Technische Universität Dresden, Germany

ABSTRACT
Teaching critical thinking (CT) is essential across all subjects, including science. However, the lack of an empirically-supported theory for developing lessons to promote CT makes teaching CT challenging. An antimatter course was developed to teach CT to secondary school students using the design-based research approach. In the main study, physics teachers implemented the 10 to 12-lesson course in 3 classes. To evaluate the impact of the course on CT, student and teacher perspectives were examined. Video, audio, student work, and interviews or questionnaires were analyzed using the constant comparative method to identify students' learning process. Inductive analysis showed that the antimatter course engaged students in the processes of applying content knowledge, applying CT skills, and developing disposition that correspond to a developed CT. Further analysis related facets of the course design to this development. Teachers' questionnaire responses indicated their positive perception of the relevance, practicality, and effectiveness of the course in promoting students' CT. Overall, the results showed the effectiveness of the antimatter course in promoting students' CT and that its design principles work well. The design principles of the antimatter can contribute to the theory of instructional design to help teachers to design effective lessons for promoting students' CT.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Exploring Sense, Trust and Belonging
18-Mar-24, 3:45 PM-5:15 PM
Location: Governor's Square 10

Examining the Relationship Between Autonomy and Sense of Belonging Among Aspiring Healthcare Providers
Joey Marion*, North Carolina State University, USA

Soonhye Park, North Carolina State University, USA

ABSTRACT
Healthcare disparities are a growing problem, underscoring the need for diversifying healthcare professionals. However, underrepresented groups struggle with persistence in science fields, coupled with the rigorous academic journey healthcare aspirants must undertake. In Self-Determination Theory by Ryan and Deci, meeting psychological needs is critical for fostering motivation and wellness in educational pursuits. These needs are interdependent, with autonomy playing an important role in mediating the other needs. This study aimed to examine the nuanced interplay between autonomy and relatedness focusing on a sense of belonging. In examination of this unique relationship, 303 prospective healthcare students in undergraduate anatomy and physiology were surveyed using a validated instrument measuring autonomy and sense of belonging. Regression analyses were employed across three models exploring autonomy as a predictor of belonging. Statistical significance in gender, race, sexual orientation, and intended healthcare field was uncovered in the relationship of these two constructs, especially concerning student connections to their instructors. This study highlights the imperative of nurturing autonomy in the science classroom, as it emerges as a cornerstone for cultivating a sense of belonging. Such an effort holds promise for enhancing the persistence of underrepresented students and further fostering greater diversity within the healthcare profession.

Exploring Student Trust in Science by the Tentative Nature of Science, and Epistemological Beliefs

Asghar Gill*, Western Michigan University, USA
Betty Adams, Western Michigan University, USA
Ramakrishna Guda, Western Michigan University, USA
William Cobern, Western Michigan University, USA
Anum Khushal, University Of Nebraska, USA

ABSTRACT
The nature of science (NOS) and epistemological beliefs (EBs) are closely related research areas that emphasize the tentative nature of knowledge and its uncertain aspects. However, an over-emphasis on the tentative NOS might raise doubts about the trustworthiness of scientific information. This study investigates the impact of a simple teaching intervention that focuses on promoting awareness about durable and trustworthy NOS to foster student trust in science and their commitment to the accuracy of scientific knowledge. Further, this study examines correlations between trust in scientific knowledge, views on tentative NOS, and EBs about the certainty of knowledge. The study employs a mixed-method intervention design with undergraduate science majors at a large US university. The findings revealed that the simple teaching intervention while yielding better results than the control conditions, did not significantly impact student trust in scientific knowledge. However, trust in scientific knowledge showed positive correlations with views on tentative NOS and commitment to the accuracy of scientific knowledge, while negatively correlating with beliefs about the certainty of knowledge. Notably, a positive correlation was found between student NOS views and EBs. The implications for teaching and learning, as well as future research directions, are discussed considering these results.

Exploring Undergraduate Students' Momentary Anxiety in Introductory Biology Classes with Intensive Longitudinal Methods

Maryrose Weatherton*, University of Tennessee Knoxville, USA
Joshua Rosenberg, University of Tennessee Knoxville, USA
Elisabeth Schussler, University of Tennessee Knoxville, USA
Alex Lishinski, University of Tennessee Knoxville, USA

ABSTRACT
Students experience many emotions in the classroom. One notable emotion, anxiety, has been shown to impact both students' academic and affective outcomes. Historically, researchers have relied on single- or two- time point surveys to study student anxiety; however, these methods fail to capture the temporal variation and situation specificity of anxiety. In this study, we used an intensive longitudinal method to better understand how anxiety, and its variation over time, affects students. We collected intensive longitudinal data, surveys, and grades from a sample of 282 students in two introductory Biology classes. We sought to understand, first, what impacts students' rate of responding to the intensive longitudinal surveys, and then to document which factors relate to students' momentary anxiety and how momentary anxiety relates to students' course grades. We found that students who had higher anxiety early in the course responded to fewer surveys. Utilizing multilevel linear regressions, we revealed that students' momentary anxiety and final course grade were significantly impacted by demographic factors and perceptions. Further, final course grade was significantly and negatively associated with students' momentary anxiety. Our results corroborate previous findings and support the use of ESM in future studies of students' experience of anxiety and other emotions.

Socio-metacognition: Examining How High Stress Environment Reshapes Interactions

Carolina Alvarado, California State University, Chico, USA
Thanh Lê, Western Washington University, USA
Estefania Orozco-Franco*, California State University, Chico, USA

ABSTRACT
As Physics Education Research-based curriculum continues to support a student-centered approach by having students collaborating in the resolution of confusion, there is a need to better understand how students' engagement in socio-metacognition is affected in high confusion and stress levels. In this qualitative case study, we examine the shift of students' socio metacognitive patterns during a lesson with reported high levels of stress and confusion. We examine their interactions during the lesson and their reflections during a follow-up interview where they watched a clip of such impasse. We observe students' dialogues aligning with the recognition of Borge's socio-metacognition framework either in its presence or absence. The results show the complexity of managing the collective information synthesis and knowledge negotiation in a group setting.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Mathematics in Science Classrooms
18-Mar-24, 3:45 PM-5:15 PM
Location: Plaza Court 7

Ships in the Night: Mathematics and Science Sensemaking in Four Chemistry Classrooms
Desi*, University of Minnesota - Twin Cities, USA
Gillian Roehrig, University of Minnesota - Twin Cities, USA
Anita Schuchardt, University of Minnesota - Twin Cities, USA

ABSTRACT
Studies across disciplines show that students struggle to solve quantitative science problems because they fail to engage in blended sensemaking (make connections between mathematical equations and scientific phenomena). This failure has been attributed to instruction that fails to connect mathematics and science sensemaking. Only one study in biology has examined mathematics and science sensemaking during instruction of mathematical equations in science classrooms. This case study extends this research to explore science and mathematics sensemaking opportunities when four instructors teach mathematical equations associated with a chemistry phenomenon, Gibbs free energy. Similar to prior study, each instructor exposed students to both science and mathematics sensemaking, but the sensemaking in these two areas were usually presented separately. Blended sensemaking only occurred in three instances across all four instructors' lessons. Students were thus deprived of the opportunity to move beyond mathematics and science as fragmented and disconnected disciplines and make connections between the two disciplines that could enhance their problem solving. These studies suggest that instructors in both biology and chemistry may benefit from professional development or curriculum that facilitates making connections between mathematics and science sensemaking. This research can be expanded to K-12 science classrooms where mathematical thinking is also a key component.

Instructional Sequence Matters: Problem-Solving First Approach Leads to Superior Transfer Learning Outcomes in Introductory Biology
Cheng-Wen He*, University of Georgia, USA
Logan Fiorella, University of Georgia, USA
Paula Lemons, University of Georgia, USA

ABSTRACT
This study compares the effects of two instructional sequences on students' transfer of learning. The design of this study aims to resolve a debate about when students should receive explicit instruction–before or after engaging in problem solving. This debate arises from two prominent instructional design theories: cognitive load theory and productive failure theory. To address the debate, this experimental study examined the effects of the instruction-first (I-PS) and the problem-solving-first (PS-I) approaches on students'

understanding of a challenging concept in the biological sciences: noncovalent interactions. We randomly assigned 367 introductory biology undergraduates to the I-PS or PS-I groups. All students received a pre-test, an instruction phase, a problem-solving phase, and a post-test. The two groups only differed in the sequence of the instruction phase and problem-solving phase. The near-transfer results indicate that the PS-I students were more competent in transferring knowledge across comparable contexts than the I-PS students. The far-transfer results suggest that the PS-I students demonstrated a greater ability to transfer their reasoning across divergent contexts than their I-PS group counterparts. Our findings support the productive failure theory and the PS-I approach, providing valuable guidance to introductory biology instructors regarding instructional sequences.

Characterizing the Learning Environment for Quantitative Reasoning Skills in Undergraduate Biology

Anum Khushal*, University of Nebraska, Lincoln, USA
Lyrica Lucas, University of Nebraska, Lincoln, USA
Robert Mayes, Georgia Southern University, USA
Brian Couch, University of Nebraska, Lincoln, USA
Joseph Dauer, University of Nebraska, Lincoln, USA

ABSTRACT

Quantitative reasoning (QR) is an important skill that helps students in making sense of biology phenomena and preparing them for future careers. Biology educators are working to improve students' QR by introducing math-integrated biology courses and conducting extensive research in teaching and learning of QR. Our study aims to characterize the learning environments whereby instructors incorporate quantitative reasoning in undergraduate biology instruction. We hypothesized that instructors create learning environments that are conducive to QR dimensions including quantitative act (QA), modeling process (MP) quantitative interpretation (QI), and metamodeling (MM). Twenty US-based biology instructors provided their video-recorded biology lesson integrating QR and were engaged in semi-structured interviews exploring their pedagogical content knowledge at the interface of math and biology. We found that instructors who use more QR dimensions better engage students in QR. Additionally, the instructors created such opportunities for students to mitigate math anxiety, integrate math and biology concepts, and use their math knowledge in real-world biology phenomena. The study findings will help biology educators and researchers better understand the classrooms where QR is implemented in biology instructions and potentially motivate more research and teaching about QR In undergraduate biology courses.

Students' Understanding of Rate of Change Within a Graphical Representation of Population Growth

Brock Couch*, University of New Hampshire, USA
Melissa Aikens, University of New Hampshire, USA
Sydney Blakc, University of New Hampshire, USA
Christi Donatelli, University of New Hampshire, USA
Nigar Altindis, University of Alabama, USA

ABSTRACT

Despite the emphasis on interpretation, graphical representations for rate of change are highlighting implicit information that requires students to coordinate two variables to gain an understanding of the figure. An introductory biology topic which highlights rate of change is population growth. To understand students' reasoning on a graphical representation of population growth, we created a pre-post assessment that provided students with a prompt related to a line graph followed by four open-ended questions. From the assessment, we conducted thematic analysis on one of the open ended question, which focused on students identifying highest and lowest rates of change. We found that in the pre-assessment 44.1% of students correctly identified the highest rate, and 52.9% for the lowest rate. For the post assessment, 38.2% identified the highest rate correctly and 48.5% for the lowest rate. We found that there was more variation in student reasoning when students incorrectly identified the highest or lowest rate. When looking across the codes, we came to three themes: 1) Students struggle with slope/height confusion; 2) Relating steepness of the line to rate can be productive for determining rate; 3) Few students used biological concepts to reason about growth rate.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set
Engaging Youth in Interest-based Science Learning Contexts
18-Mar-24, 3:45 PM-5:15 PM
Location: Governor's Square 16

Cosplaying Scientists Use Theoretically-Based Science Communication Techniques at Comic Cons

Lisa Lundgren*, Utah State University, USA
Kadie Kunz*, Utah State University, USA
Emily Slater*, Utah State University, USA
Man Zhang, Utah State University, USA

ABSTRACT

Science communication studies often focus on traditional informal STEM learning spaces, such as museums. While these environments provide important contexts, they are limited as they are often frequented by wealthy, white visitors. To determine if science communication techniques apply in other, more diverse contexts, we integrated two conceptual frameworks, effective framing (Druckman & Lupia, 2017) and narrative structuring (Dahlstrom, 2014), to describe aspects of educative science communication efforts used by cosplaying scientists. We found that within the everyday space of comic cons, scientists employed theoretically-based science communication techniques including narrative and framing science in ways that apply to peoples' interests. The results of this study are important as they indicate that theoretically-based science communication techniques can be employed in environments attended by diverse audiences.

High School Science and Engineering Fairs: Science for Everyone

Frederick Grinnell*, UT Southwestern Medical Center, USA
Simon Dalley, Southern Methodist University, USA
Joan Reisch, UT Southwestern Medical Center, USA

ABSTRACT

In recent years, ideas about how best to accomplish science education have focused increasingly on hands-on science and engineering (S&E) practices. Science and engineering fairs (SEFs) offer students the opportunity to experience for themselves the practices of science and engineering described by Next Generation Science Standards (NGSS). SEFs potentially can promote three important and desirable outcomes: (i) mastery of S&E practices; (ii) interest in science; and (iii) interest in science careers. The goal of our research is to develop a national base of knowledge regarding student experiences in high school SEFs. Having this information could help identify best practices leading to more effective, inclusive, and equitable SEF learning opportunities thereby enhancing successful student participation and outcomes including the idea of science for everyone, one of the original goals when SEFs were introduced in the 1930's, and theme of this conference. Because high level SEF competitions receive so much attention, the more general value of SEFs as a STEM education tool can easily be overlooked. Our findings regarding students' SEF experiences provide important insights into the more general value of student SEF participation.

Supporting Youth STEM Learning and Growth Mindsets Through Baseball-Themed Activities in Informal Education Settings

Christina Baze*, Northern Arizona University, USA
Sanlyn Buxner, University of Arizona, USA
Seneca Miller, University of Arizona, USA
Erin Turner, University of Arizona, USA
Ricardo Valerdi, University of Arizona, USA

ABSTRACT

A substantial problem with STEM education over the past half-century has been that we have focused on producing more scientists, engineers, computer scientists, and mathematicians, rather than providing high-quality core STEM learning for all of our students. Informal learning contexts are also important sites of STEM learning and can provide access to STEM learning for youth who otherwise may not have sufficient opportunities to engage in STEM. In this study, we focus on the outcomes for youth related to growth mindset around sports and STEM and math learning. We analyzed both qualitative and quantitative data from facilitators and youth who participated in eight implementations of [the project] across three states. Findings overall show that [the project] supported youth math learning and engagement through the integration with baseball and connections between math and real-world contexts and supported the understanding and development of a growth mindset related to both sports and math. These findings will be of interest to the informal STEM education community as a model for integrating STEM and real-world contexts for youth, particularly those from underserved communities.

Exploration of Play as a Vital Strategy to STEM Literacy
Sue Tunnicliffe*, University College London, United Kingdom
Adekunle Oladejo, Lagos State University, Nigeria
Peter Okebukola, Lagos State University, Nigeria
Ibiyinka Ogunlade, Ekiti State University, Nigeria
Juma Shabani, University of Burundi, Doctoral School, Burundi
Rose Agholor, Lagos State University, Nigeria
Deborah Agbanimu, Lagos State University, Nigeria
ABSTRACT
The use of play as an effective tool and link for STEM education has proved to be a workable strategy, in popularizing STEM among children at an early age. Play, a primary means by which children explore their immediate environment has served as a catalyst for their understanding and interest in basic theoretical frameworks such as Piaget and Vygotsky. This study spanned over a two-year period. It employed a non-participant observer methodological approach, on a playground where the observed children were able to explore STEM concepts. The participant reported were three boys and one girl from less than one to three years involved in a series of plays on a playground. The result showed that the children's attention and interest were caught, maintained and sustained in STEM-Experiences from the preschool years to formal school age. There is also a distinct progression of capability in the mastery of STEM fundamental principles by the children. It is therefore concluded, that NARST members whose research interest focused on early/primary science learning would find this study on the use of Play for STEM learning at the early childhood stage highly beneficial.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Exploring Various Components Within Preservice Teacher Education
18-Mar-24, 3:45 PM-5:15 PM
Location: Plaza Court 4

Influence of Pre-Service Teachers' Interactive Use of Content-Specific Knowledge Components From Students' Point of View
Olutosin Solomon Akinyemi*, University of the Witwatersrand, South Africa

ABSTRACT
This paper reports on the qualitative examination of students' views about the influence of pre-service teachers' teaching on their learning of Organic chemistry. The examination employed the content-specific knowledge components of topic specific pedagogical content knowledge (TSPCK) (Mavhunga & Rollnick, 2013) as a theoretical lens. The participants were three pre-service teachers who delivered two lessons each focusing on Organic chemistry during a school-based practicum attended by 74 physical sciences Grade 12 students. The data collected were the video recordings of the pre-service teachers' teaching, stimulated recall interviews conducted with the pre-service teachers, and students' views collected

through focus group semi-structured interviews following the pre-service teachers' teachings. The findings revealed that the students' descriptions of what contributed to their learning reflected, in a similar way, the pre-service teachers' understanding of the importance of the interactive usage of content-specific knowledge components of TSPCK as a key factor. The implication and recommendation for teachers are that the possession of different content-specific knowledge components of TSPCK and their interaction is essential as it is what is visible to students as the factor contributing their learning.

Elementary Education Majors' Grades in General Education Courses: Comparisons with Other Majors

Ryan Nixon*, Brigham Young University, USA
Elizabeth Bailey, Brigham Young University, USA

ABSTRACT

Many teacher preparation programs are designed to have preservice elementary teachers learn science content in general education science courses. Scholars have criticized this design, which has preservice teachers learning foundational knowledge in contexts not designed for them. To better understand the effectiveness of these courses for elementary education majors we investigate the grades of elementary education majors in general education courses as compared to other majors. Using a data set with the grades from 195,861 students in six courses over ten years, we find that students who graduate with an elementary education major perform similarly to students with other majors in general education courses. This is the case when considering just science general education courses, which elementary education majors may see as having limited relevance to their future careers. This is also the case with a course that is easily relevant to elementary education majors' work. Furthermore, this similarity in grades holds when considering grades from six different general education courses. In short, no meaningful differences were identified between elementary education majors and students in other majors. However, this does not provide evidence of the depth of their learning in these courses or the usefulness of these courses for teaching.

Course Modalities: Challenges and Benefits in Preservice Teacher Science Content Courses from Instructors and Students

Preethi Titu*, Kennesaw State University, USA
Jessica Reaves*, Kennesaw State University, USA
Anna Arias, Kennesaw State University, USA
Soon Lee, Kennesaw State University, USA

ABSTRACT

Online higher education has grown remarkably and the number of students taking online courses, including courses for preservice teachers has been on the rise. Given the importance of providing meaningful learning opportunities for pre-service teachers (PSTs), this study examines both instructors and PSTs' views of the benefits and challenges of providing specialized content courses in different modalities that includes face-to-face, hybrid, and asynchronous online. Using qualitative methodology, the researchers analyzed two major

data sources - instructors' reflections on teaching in different modalities and students' responses on surveys about their experiences taking the courses in different modalities. Major themes that arose in the analyses of the instructors' experiences included a) flexibility; b) sense of community and communication; and c) engagement in class and written work. The students' responses highlighted communication, engagement in investigations, working at their own pace, and motivation. Often, the benefits of face-to-face and hybrid courses such as the flexibility to make adjustments for student needs, interests, and strengths was a challenge in asynchronous online learning where instructors often were not able to learn about their students or develop a sense of community. The findings have implications for teacher educators and designers in supporting PSTs' learning across different modalities.

Developing a Learning Progression-based Module For Preservice Elementary Teachers: A Pilot Study

James Hancock II*, Alma College, USA
Amanda Harwood, Alma College, USA
Jessie Store, Alma College, USA
Julie Christensen, Michigan State University, USA

ABSTRACT

Teachers need a strong understanding of the content that they teach, and when they are less knowledgeable their instruction can be less responsive to students. Teacher education programs must also consider how to support preservice teachers' (PSTs') understanding of student ideas. Learning progressions (LPs) are one tool that explicates how students' ideas may increase in sophistication with instruction. We hypothesized that supporting PSTs to reflect on the student ideas in LPs alongside instruction in a college-level science course may support them in learning science and improve their understanding of student ideas. In this pilot study we developed a learning progression-based module (LPM) that drew on Alonzo & Steedle's (2009) force and motion LP. The LPM included activities to engage PSTs in 1) learning about common student ideas, 2) ordering those common student ideas, and 3) reflecting on their own developing science ideas. In this poster we present preliminary findings from our mixed methods pilot study, which suggest the LPM supported PSTs in improving their understanding of force and motion as well as of common student ideas, but raise important questions about PSTs' perceptions of their own learning.

Strand 7: Pre-service Science Teacher Education

SC-Organized Paper Set

Research Approaches Investigating Mentoring, Discourse patterns, and Science Core teaching Practices

18-Mar-24, 3:45 PM-5:15 PM

Location: Plaza Court 3

Science Pre-Service Teachers' Experience with Mentor Teachers during Teaching Practice

Tafirenyika Mafugu*, University of the Free State, South Africa

ABSTRACT
This study aims to explore how mentor teachers and the school environment helped preservice teachers develop their pedagogical skills, and thereby, closing the gap between theory and practice. The study is based on a survey research design consisting of 75 participants consisting of third and final-year students at a research and teaching university. The participants completed a Google survey questionnaire with responses on a five-point Likert scale from strongly disagree to strongly agree. The results indicate that although most preservice teachers received the necessary guidance in theory and practical lessons as well as assessment, a significant proportion of the participants were not adequately assisted. A large proportion of the schools did not have laboratories, laboratory equipment, and chemicals. The study has practical implications for the professional development of science teachers before service. There is a dire need for all science preservice teachers to be adequately developed by selecting the appropriate context in which the teaching practice is done to develop the knowledge, science-specific pedagogical skills, and values necessary for successful entry into a professional career. Furthermore, mentor teachers need to be properly oriented about their mentoring roles, and the school management team must assist in monitoring the mentoring process.

The Critical Role of Mentoring for Preservice Science Teachers: Relational, Developmental, and Contextual Dimensions

Maria Rivera Maulucci*, Barnard College, Columbia University, USA
Julie Contino, American Museum of Natural History, USA

ABSTRACT
This study aims to explore the critical role of mentoring in fostering positive outcomes for undergraduate science teaching interns. This project provides undergraduate STEM majors with a summer teaching experience hosted in collaboration with a science museum, a liberal arts college, and a local school district that hosts the summer school program for high school students. Interns are recruited from local two- and four-year colleges with high representation of underrepresented groups in STEM. The program includes a science pedagogy course, culturally sustaining methods for teaching racially and culturally diverse high school youth, opportunities to co-plan and co-teach a 4-week summer high school course in earth and climate science, close mentoring by master teachers, and regular observations and feedback. The pedagogy course, taught by a science education specialist from the museum who also is a current high school Earth Science teacher, focuses on subject-specific pedagogy aligned with the Next Generation Science Standards. Mentor teachers have two orientation sessions covering the program's history, expectations, mentoring others, mentoring tools, giving feedback, mentoring practice, and coteaching models.

A Study on Discourse Patterns in Secondary Science Classroom Based on Lag Sequential Analysis

Xinhao Song*, Beijing Normal University, China
Yixuan Liu, Beijing Normal University, China
Yuanyuan Fang, The Second High School Attached To Beijing Normal University, China

Jianxin Yao, Beijing Normal University, China
Chunmi Li, Beijing Normal University, China

ABSTRACT
Classroom discourse is an essential component of classroom interaction. To analyze the discourse patterns in the science classroom, we select the classroom discourse of pre-service physics teachers and expert physics teachers as the object of this study. By using GSEQ to conduct classic lag sequential analysis, we summarize the significant discourse patterns of pre-service teachers and expert teachers. In our study, we find that there is a certain gap between the classroom discourse of pre-service teachers and expert teachers. Pre-service science teachers' classroom discourse has several defects, such as less surfacing questions, low feedback quality and fast class rhythm. Based on the research results, three suggestions are put forward for the professional development of pre-service science teachers: ask more surfacing questions and prolong the waiting time, optimize feedback based on pedagogical decision, make good use of neutral feedback to slow down the pace of class.

Emerging Themes in a Study Around Science Core Teaching Practices: Examining Two Universities' Coursework
Dominick Fantacone*, SUNY Cortland, USA
Elizabeth Edmondson*, Virginia Commonwealth University, USA
Elaine Howes, American Museum of Natural History, USA
Jamie Wallace, American Museum of Natural History, USA

ABSTRACT
Shifts in instructional expectations related to science education reform has resulted in teachers needing requisite pedagogical knowledge and skills. It has been suggested that teachers engage with a set of core instructional practices to support student learning. For teacher educators, there is a responsibility in understanding how and if preparation programs are preparing pre-service teachers for success in their future science classrooms. Our research question considers the coursework of two university Noyce programs and how they prepare new teachers for enacting particular core science teaching practices. In this study, we apply a qualitative case study across the data from faculty, leadership, graduates, host teachers, and course syllabi at both universities. Four themes surfaced: a focus on core science teaching practices; conveying strong content knowledge; modeling high expectations for teacher candidate learning; and experiences during the pandemic. Findings suggest that not only do faculty, graduates and mentors recognize the instructional components as essential, they highlight them as prominent. The more we discuss commonalities, successes, and challenges of our programs, the better our community will prepare our graduates for the students that await them.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Innovative Models of Teacher Professional Development
18-Mar-24, 3:45 PM-5:15 PM
Location: Plaza Court 5

Decomposing Teacher Response - Elementary Science Noticing within an Interactive Model of Professional Learning

Linda Preminger*, California State University East Bay, USA
Kathryn Hayes, California State University East Bay, USA
Dawn O'Connor, Alameda County Office of Education, USA

ABSTRACT
The three dimensions of the NGSS represents an enormous professional learning challenge, especially in elementary contexts, where teachers often feel unprepared, and science instruction is underdeveloped and de-emphasized. Because reform-based practices require comprehensive pedagogical shifts, interactive models of teacher learning, such Clarke & Hollingsworth's (2002) Interactive Model of Teacher Professional Growth (IMTPG) may better explain the iterative nature of teacher learning than earlier linear professional development (PD) models. Yet, despite its complexity, the IMTPG does not explain differential uptake of PD learning. An intersection of the IMTPG with teacher noticing helps us better understand why teachers in the same PD vary in their ability to implement reformed instructional practices. Of the noticing skills, responding to students in-the-moment is the most challenging. This single qualitative case study analyzes the practice of an experienced elementary teacher using Luna & Selmer's (2021) decomposition of responding within the context of the IMTPG. The intersection of the two frameworks lends insight into our research questions: 1) Which domains of professional learning most influence a shift in teacher response toward reform-based science instruction? 2) How does a teacher in long-term PD use noticing response to enact instructional reforms in light of student learning in science?

Critical Dialogue and Positive Evaluation in Peer/Other Video-Based PD: The Complex Role of Facework

Miriam Babichenko, Ben Gurion University of the Negev, Israel
Dana Vedder Weiss*, Ben Gurion University of the Negev, Israel

ABSTRACT
Collaborative analysis of classroom videos has become an integral part of many teacher PD programs. In this study, we used mixed methods to compare teacher discussions when they analyzed a Peer's video versus a video of an unknown teacher (Other Video) and to explicate the findings. The data included 28 audio-recorded, fully transcribed, video-based discussions (14 Peer Videos and 14 Other Videos) collected in 28 teacher-led, teacher teams. The findings show that despite expectations for differences, Peer Videos and Other Videos resulted in roughly similar discussions on most parameters, with the exception of more positive evaluations in Peer Video than in Other. Despite the dominance of positive evaluation, Peer

video-based conversations were as rich in critical dialogue as Other Video conversations. To further explore this finding, we used linguistic ethnographic microanalysis, examining a case of one Peer Video-based discussion particularly rich in positive evaluation and critical dialogue. We examined the role positive evaluation played in the interaction, conceptualizing it as facework (Goffmann, 1955). The analysis showed how, on the one hand, the positive evaluation served as facework allowing teachers to raise critiques. On the other hand, this facework constrained the depth of pedagogical reasoning they were able to achieve.

Catalyzing Change: A Comparative Study of Science Teacher Professional Development Models and Influence on Instruction

Sierra Morandi*, Florida State University, USA
Elif Ozulku*, Florida State University, USA
Sherry Southerland, Florida State University, USA
Patrick Enderle, Georgia State University, USA

ABSTRACT

This study investigates the influence of two professional development (PD) models, Learning through Collaborative Design (LCD) and Learning through Participation (LTP), on science teachers' instructional practices. Using instructional practice rubrics, we analyzed teachers' implementation of four focal lessons to examine instructional quality. Noteworthy nuanced differences emerged between the two PD models and help to support the current understanding of the mechanisms through which PD programs exert their influence on practice.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Professional Developments' Impact on Teachers and/or Students
18-Mar-24, 3:45 PM-5:15 PM
Location: Plaza Court 2

Untangling the Effects: A Meta-Analysis Examining the Impact of Professional Development Programs for Science Teachers

Hyesun You*, The University of Iowa, USA
Sunyoung Park, California Lutheran University, USA
Minju Hong, University of Arkansas, USA
Alison Warren, The University of Iowa, USA

ABSTRACT

Previous studies on teacher professional development (PD) have seldom synthesized the extent to which PD programs effectively influence teachers' content knowledge, pedagogical quality, and further improve students' academic performance in science education. This meta-analysis study aims to evaluate the collective impact of PD programs for science teachers and their students. A total of 519 effect sizes were calculated from 67 studies published between 2010 and 2022. The overall effect size was 0.775, indicating a substantial

effect size on PD effectiveness (s.e. = 0.061, p < .001). Considerable heterogeneity of effect sizes was observed, moderated by PD dosage hours, duration, and active teaching. The findings indicate that relatively short PD periods—less than 48 hours—and durations under three months may yield more effective science PD for educators. Conversely, slightly lengthier engagement exceeding 72 hours, coupled with sustained support over six months, could engender relatively successful PD endeavors. Furthermore, an active learning approach within PD programs (g_ = 0.794, s.e. = 0.066, p < 0.001) emerged as a pivotal aspect influencing PD effectiveness. This study provides insights into education research and policy to understand PD research and to ensure how PD can be designed and implemented so that student performance improves.

Mentorship and Professional Development in Science Education: A Self-Determination Theory Framework for Understanding Teachers' Perspectives

Mayra Marquez-Mendez*, University of Nevada Las Vegas, USA
Adjoa Mensah*, University of Nevada Las Vegas, USA
Tina Vo, University of Nevada Las Vegas, USA

ABSTRACT

The present study investigates the significance of mentorship in supporting science teachers' growth and development within the context of evolving education demands. Test mandates and standardized testing often put teachers under pressure to neglect their own development (Ball, 2009; Burris, 2012; Zeichner, 2016). Recognizing the potential of mentorship to address these challenges, the study explores how science teachers conceptualize mentorship. Using the self-determination theory (SDT) framework, which emphasizes autonomy, competence, and relatedness, to examine how mentorship matches the psychological needs of teachers. Teachers' mentorship preferences are compared through qualitative analysis of their responses. Findings demonstrate that autonomy-oriented support is preferred by elementary school teachers, while middle school educators prefer competency-focused support. The findings emphasize the importance of mentoring for teacher retention, professional growth, and successful science education. As a result of this research, teachers and diverse student populations could experience enhanced science instruction, collaborative classroom environments, and tailored professional development strategies. Mentorship relationships become increasingly important as science education evolves in order to foster effective teaching.

Teacher-Student Co-Learning: A Hybridization of Teacher Professional Learning With Student Out-of-School Learning

Xornam Apedoe*, University of San Francisco, USA
Andrew Barham, University of San Francisco, USA
Megan Fu, University of San Francisco, USA
Katherine Nielsen, University of California San Francisco, USA

ABSTRACT

Our paper presents a case for co-learning, a novel hybridization of teacher professional learning and student out-of-school learning. Because of its novelty, both questions and

skepticism exist about co-learning as a professional learning model. We believe it offers great promise, and thus this study is a first step at exploring teachers' experiences with co-learning to better define its strengths and limitations. We will share insights gained from implementing a unique summer workshop that utilized the co-learning model, in which teachers and students are provided an innovative introduction to cellular engineering, computational thinking (CT), and engineering design by using robots as a model of cells.

Impact of an Online STEM Professional Development Program for K-3 Teachers on Student Outcomes

Kadir Demir*, Georgia State University, USA
Ryan Duckett, University of Toledo, USA
Christopher Wojciechowski, University of Toledo, USA
Charlene Czerniak, University of Toledo, USA
Susana Hapgood, University of Toledo, USA
Joan Kaderavek, University of Toledo, USA

ABSTRACT

The purpose of this study was to examine the impact of an online STEM professional development (PD) program that utilized Next Generation Science Standard's three-dimensional learning as an approach for K-3 teachers on grade 1-3 student learning in science and mathematics. This study presents findings from two years implementation of PD in participating schools in the states of Georgia, New Mexico, Ohio, South Carolina, Virginia, and Washington. The Galileo K-12 online tests were utilized for pre- and post-testing of student learning. Forty-six elementary teachers across grades 1-3 in six states administered the tests. Data were collected from 277 students. Descriptive statistics of the students' percent attainment and national percentiles in mathematics and science were used. Further, a random-intercept mixed regression model was used to assess the impact of time or intervention from pre-to-post assessment of students' scores. Hedges' g effect sizes for dependent samples were computed to obtain standardized measures of students' gains, which were significant. The descriptions in the presentation can support others advance effective science/STEM teaching practices at early elementary levels to implement three-dimensional learning.

Strand 10: Curriculum and Assessment
Related Paper Set
Curriculum Materials Adaptations: What Teachers Attend to and the Changes They Make

18-Mar-24, 3:45 PM-5:15 PM
Location: Plaza Court 6

Un/making Curriculum Materials: Teachers' Localized Adaptations of Curriculum Materials in Context

Emily Seeber*, University of Michigan, USA
Christa Haverly*, Northwestern University, USA

Elizabeth Davis*, University of Michigan, USA

ABSTRACT
Curriculum materials are considered a key lever in instructional reform in elementary science, yet teachers' uptake and use of curriculum materials is enmeshed in a series of relationships with sociomaterial organizational structures that shape their practice. In this sense, curriculum materials can be understood as a "seed" that dynamically evolves within localized contexts. As such, contrary to a logic that suggests distributing curriculum materials is sufficient for teachers to enact reformed teaching practices, this paper frames the uptake and use of curriculum materials as an ongoing and relational practice in instructional reform. To foreground this relationality, this analysis draws on posthuman feminist perspectives that theorize matter as vibrant and self-organizing. Curriculum materials shift from being mediators between standards and instruction to lively interlocutors. Posthuman feminism recognizes that knowledge production is (always) partial and perspectival, materially embodied, and subject to flows of power. As such, this study privileges the knowledge practices of elementary science teachers, centering their assets and creative powers to make meaningful instructional decisions including principled adaptations to curriculum materials, while also accounting for them as embodied and embedded in institutional contexts that constrain their work.

Flexible Tool or Verbatim Script?: Teachers' Framing and Uses of Educative Features in Curricular Materials

Soo-Yean Shim*, Seoul National University, Republic of Korea
Christina Krist, University of Illinois Urbana-Champaign, USA
Kevin Hall, University of Illinois Urbana-Champaign, USA
Mon-Lin Monica Ko, University of Colorado Boulder, USA
Tania Jarosewich, Censeo Group, USA
Barbara Hug, University of Illinois Urbana-Champaign, USA

ABSTRACT
This study explores how in-service teachers make sense of educative features in NGSS-aligned curriculum materials. Nine middle school teachers were interviewed about how they interacted with two NGSS-aligned science curricular materials. We identified 12 potential educative features in the materials and asked the teachers about how they interacted with each of the features. We used an inductive comparative coding approach to analyze the teachers' uses of the features. This presentation focuses on teachers' use of one feature, "lesson-level performance expectations." Eight of the nine teachers described it as the feature they regularly used when planning for and enacting instruction. Teachers' sensemaking about this feature reflected adaptive use of the materials. The PEs contributed to teachers' self-reported enactment and growth in three ways. First, four of the nine teachers shared that the feature helped them shape classroom interactions. Second, five of the nine teachers reported that the color-coded PEs supported them in developing their and their students' capacity about the three dimensions of NGSS. Finally, seven teachers stated that the feature helped them set direction and check their progress. The feature helped them improve their understanding of content and pedagogy and informed how they might customize enactment to their own context.

Preservice Elementary Science Teachers' Strategies for Expanding What Counts as Science

Jessica Bautista*, University of Michigan, USA
Elizabeth Davis, University of Michigan, USA

ABSTRACT

There have been increasing calls for equity and justice-oriented approaches in elementary science education, raising questions of how to best support early career teachers. Sensemaking in particular is a crucial area for addressing equity and justice goals. This qualitative study focused on five preservice elementary teachers' science lesson plans and enactments during their science methods class and student teaching, characterizing how they modified existing curriculum materials towards supporting more equitable and just science teaching. The paper explores these teachers' ideas about and support for expansive sensemaking—co-constructing knowledge to understand the natural world in ways that challenge dominant norms and assumptions. Findings suggest that preservice teachers planned for and enacted a range of instructional moves with varying degrees of sophistication. These teachers consistently worked to support children's epistemic authority and agency, leverage children's assets, and build collaborative classroom cultures. Moves that were more challenging included assigning a range of competences, incorporating non-dominant ways of knowing, and supporting translanguaging. While the preservice teachers' curricular adaptations collectively showed many strengths, each teacher struggled with some aspects of expansive sensemaking, suggesting that preservice teachers likely need additional support to effectively incorporate strategies that more directly challenge dominant narratives around science.

"Oh Yeah, That Has Happened to Me": A Teacher's Strategic Adaptation of a Phenomenon

Nicholas Leonardi*, University of Illinois Urbana-Champaign, USA
Barbara Hug*, University of Illinois Urbana-Champaign, USA
Christina Krist, University of Illinois Urbana-Champaign, USA

ABSTRACT

Developing curriculum materials with an appropriate phenomenon that both interests or connects with students and serves as a productive resource for content-focused question generation can be difficult. Therefore, curriculum adaptation provides an opportunity for teachers to customize materials in order to make them relevant to their students. This study explores how a middle school dual language program science teacher adapted the anchoring phenomenon of a co-designed curriculum during unit enactment. We completed a thematic analysis (Braun & Clarke, 2006) to find how the teacher adapted the curriculum unit's anchoring phenomenon. We identified patterns in the different functions that the teacher's adaptations served by analyzing what prompted each adaptation, the nature of the adaptations themselves, and how the adaptation played out in practice. Our findings illustrate how the adaptations were focused on supporting students in doing the intellectual work of sensemaking and designing investigations. These adaptations served as strategically crafted openings for redistributing epistemic agency to students (Ko & Krist, 2019) and show

how curricula is an evolving collection of resources through which relevance for teachers and students is negotiated and co-constructed.

Re-Tooling NGSS-aligned Curricula to Promote Agency, Ownership and Relevance

Kerri Wingert*, Good Question Research, LLC, USA
Barbara Hug*, University of Illinois Urbana Champaign, USA
Monlin Monica Ko, University of Colorado Boulder, USA
Christina Krist, University of Illinois Urbana Champaign, USA

ABSTRACT

How do teachers adapt NGSS-aligned materials to promote epistemic agency? This paper explores the impact of a professional learning workshop focused on epistemic agency and how this emphasis shapes what and how teachers adapt their curriculum materials. The project team engaged 13 middle and high school teachers in two district sites in 32 hours of professional learning (PL) during summer 2023. During the PL, teachers analyzed video cases of curricular adaptations, discussed how these change opened up opportunities for redistributing agency, and worked in small groups to make adaptations to curricular units that would be used in the fall semester. Our analysis of video recordings and artifacts that were generated in the small groups revealed that while the grain size and nature of the adaptations varied across groups, the focus on students' epistemic agency in the PD led the groups to make relevant phenomena a centerpiece of the opening lessons. These findings suggest that epistemic agency may be a powerful lens for creating purposeful adaptations to NGSS-aligned curricula for teachers with varying degrees of expertise and experience with these materials, and that these modifications can potentially make the lessons more meaningful and relevant for students.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set
Engaging Advanced Quantitative Techniques in STEM Education in Pursuit of Justice
18-Mar-24, 3:45 PM-5:15 PM
Location: Governor's Square 14

Measuring Justly in Mostly White Schools: A Case for Psychometric Effect Coding

Phillip Boda*, University of Illinois Chicago, USA
George Sirrakos, Kutztown University of Pennsylvania, USA
Lisa Frye, Kutztown University of Pennsylvania, USA
Joleen Greenwood, Kutztown University of Pennsylvania, USA

ABSTRACT

Núñez et al. (2024) brings multiple fields of study into discussion around how to approach a critical quantitative episteme seriously in ways that honor intersectionality's multi-layered and multi-dimensional components that multiply as they are added into our inferential and causal analyses. In predominantly white spaces (PwS), the effects of these components that

describe the structural, political, and representation nature of intersectionality are often estimated compared to a reference group, and Tabron and Thomas (2023) showcase how Effect Coding to disrupt this practice of inter-group 'gap-gazing' and become more sensitive to the ways that intra-categorical heterogeneity tells a different story than what we've heard before. I argue in this paper that this same issue is something that psychometrics needs to wrestle with, and more specifically among our Science, Technology, Engineering, Mathematics, and Medical (STEMM) education research. This research asks: How can we measure justly in mostly white spaces with our instruments?

Society's Educational Debts in Biology, Chemistry, and Physics: Race, Gender, and Class

Ben Van Dusen*, Iowa State University, USA
Jayson Nissen, Nissen Education Research and Design, USA
Odis Johnson, John Hopkins University, USA

ABSTRACT
The success of collaborative instruction in helping students achieve higher grades in introductory science, technology, engineering, and mathematics (STEM) courses has led many educators and researchers to assume these methods also address inequities. However, little evidence tests this assumption. Structural inequities in our society have led to the chronic underrepresentation of Black, Hispanic, women, and first-generation students in STEM disciplines. Broadening participation from underrepresented groups in biology, chemistry, and physics would reduce social inequalities while harnessing diversity's economic impact on innovation and workforce expansion. We leveraged data on content knowledge from 18,791 students in 305 introductory courses using collaborative instruction at 45 institutions. We modeled student outcomes across the intersections of gender, race, ethnicity, and first-generation college status within and across science disciplines. Using these models, we examine the educational debts society owes college science students prior to instruction and whether instruction mitigates, perpetuates, or exacerbates those debts. The size of these educational debts and the extent to which courses added to or repaid these debts varied across disciplines. Across all three disciplines, society owed Black and Hispanic women and first-generation Black men the largest educational debts. Collaborative instructional strategies were not sufficient to repay society's educational debts.

Active Engagement Strategies in Undergraduate Calculus: Learning How to Sustain Success for URM STEM Majors

Zenaida Aguirre Munoz*, University of California, Merced, USA
Mayya Tokman, University of California, Merced, USA
Lalita Oka, California State University, Fresno, USA
Keith Thompson, University of California, Merced, USA
Erica Rutter, University of California, Merced, USA
Khang Tran, California State University, Fresno, USA
Lei Yue, University of California, Merced, USA

ABSTRACT
Performance in Calculus courses is a major barrier to students' progress in STEM majors. The problem is amplified for underrepresented minoritized students (URMs) and first-generation college students. Extant literature and guidance increasingly point to the need to address the psychosocial factors to bolster resilience, persistence, and self-concept in science, technology, engineering, and mathematics (STEM) fields. Improving Calculus experiences, thus, requires understanding the individual and classroom variables that impact URMs performance in first year calculus courses. A traditional approach to delivery of calculus involves lecture-based format with instruction and assessment focused on mathematical techniques like the mechanics behind computing derivatives of integrals. Using HLM analyses, we show that psychological factors can impact course performance, however, active learning is a stronger predictor of course performance, particularly for URM STEM Majors. These results indicate that equity in STEM requires innovation in supporting students' beliefs about themselves and the discipline as well as transforming instruction to more active learning approaches that motivate students to persist and thrive.

How Measures of High School STEM Orientation Predict College Enrollment. Monitoring Equity in Science Opportunities.

Vandeen Campbell*, Rutgers University, Newark, USA
Jiwon Hwang, California State University, Los Angeles, USA
Jessica Zulawski*, Newark Board of Education, USA

ABSTRACT
Inclusive STEM focused high schools, which have a declared STEM theme are recognized for their potential for broadening STEM participation for underrepresented students and deepening STEM learning and interest. Even with the established value of inclusive STEM-focused high schools, one lingering concern is with a sense of rationing of educational opportunity for students who are not in these specialized schools. While acknowledging the benefits of attending STEM-focused schools, we posit that there could be an inherent educational injustice when advantageous educational opportunities are not baselined into our evaluation or expectations of schools across the board. If we think of the STEM focus of high schools on a spectrum, an opportunity to monitor equity in systematic ways may be apparent. Using proxy measures to study STEM-focus or, more conservatively, STEM orientation, can be useful for understanding high school prioritization of STEM and how it predicts college outcomes. The study investigates the following research question: Can attending a high school with greater STEM orientation increase students' odds of college enrollment? Cross-classified hierarchical linear models were used to test the effects of attending a STEM oriented high school. High school STEM orientation emerged as a strong positive predictor of college enrollment.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Refusing Damage-Centered Narratives in Postsecondary STEM Education: Resistance, Thriving, and Desire
18-Mar-24, 3:45 PM-5:15 PM
Location: Governor's Square 12

Science Education for Us: Black Males Exercising Resistance to Matriculate through STEM Education
Takeshia Pierre*, University of Florida, USA
Jomo Mutegi*, Old Dominion University, USA

ABSTRACT
Black Males continue to be underrepresented in STEM fields. In recent years, scholars have argued that current issues with retention in STEM majors have less to do with Black students' mastery of STEM topics, and are more relative to the hostile environments they experience in their effort to obtain STEM degrees. Statistics show that Black Males leave STEM majors in record numbers, which can in part explain their relatively low representation in STEM fields. Considering the conference theme "Science for the Rest of Us," we document the experiences of 50 Black Males who currently hold careers in STEM fields, acknowledging and amplifying voices that commonly experience erasure in these settings. We highlight moments these men exercised resistance to maintain their placement in STEM environments and remained in their respective fields. We seek to answer the research question: What experiences shape the career trajectory of Black Male STEM professionals and how do those experiences and their response to them lead to career persistence? We present 3 major findings: 1) Existence as Protest: Black Males Occupying STEM Spaces, 2) Acknowledging Hurdles, Surpassing Low Expectations, and 3) Making Broader Impacts. Future implications for research and suggestions for the NARST community are discussed.

Utilizing an Asset-Based Lens to Examine How Women of Color Thrive in STEM
Anina Mahmud*, University of North Carolina, USA
Dionne Cross Francis*, University of North Carolina, USA
Pavneet Kaur Bharaj, California State University, USA
Kerrie Wilkins-Yel, University of Massachusettes, USA
Aishwarya Shridhar, University of Massachusettes, USA
Dionne White, Indiana University, USA

ABSTRACT
While there has been increased attention on the enduring issues of underrepresentation of Women of Color (WoC) in STEM, many of these studies take a deficit perspective on the experiences of WoC citing lack of interest and abilities on their part. This perspective attributed their marginalization to some form of deficiency in the skills of the women themselves or their culture. However, despite the challenges faced in isolating and hostile STEM environments, WoCs persist and thrive. Utilizing Yosso's (2005) community cultural

wealth as a lens to explore the experiences of WoC, we present a counternarrative describing the resources WoC leverage as they navigate their STEM programs. Thirty-eight WoC enrolled in STEM programs across three universities, who self-identify as women from a racially/ethnically minoritized community, reflected on their interests, experiences, and motivations to pursue a STEM education and career. Thematic analysis of their transcribed reflections showed that these participants primarily leveraged their familial, aspirational, and navigational to persist and succeed amidst the challenging culture of their STEM programs.

"I Just Got Lucky": Multiply Marginalized Students' Experiences with Mentorship in the Medical Education Trajectory

Candice Kim*, Stanford Graduate School of Education, USA

ABSTRACT

Decades of prior research has demonstrated the underrepresentation of Black and Brown students in the medical education trajectory, starting in the premedical undergraduate track through medical school and residency. This qualitative study operationalizes Disability Critical Race Theory (DisCrit) to center the counterstories of Black and Brown students who also identify as first-generation college students and/or low-income (FLI) across this trajectory. Specifically, this study examines the processes that support Black and Brown FLI students' persistence in the medical education trajectory, revealing the critical ongoing role that K-12 teachers play. Semi-structured interviews with Black and Brown FLI premedical undergraduates, medical students, and residents reveal the struggles they encounter in accessing strong mentorship from faculty and administrators at their higher education institutions. Former K-12 teachers often serve to patch this gap in mentorship by continuing to offer guidance and emotional support to their former students well beyond their time in their classrooms. These findings emphasize the systemic changes needed to improve higher education mentorship based on practices previously found to be successful in K-12 education to better serve multiply marginalized students—and ultimately diversify the medical profession.

Desire-Based Research for Alternative World-Building: Possibilities and Tensions for Research in STEM Education

sarah El Halwany*, Université de l'Ontario, Canada
Kristal Turner*, University of Calgary, Canada
Kristen Schaffer, Mount Royal University, Canada
Jennifer Adams*, University of Calgary, Canada

ABSTRACT

In this paper, we engage with a desire-based framework to think with racialized and historically minoritized students' experiences in postsecondary STEM. In contrast to damage-centered research, desire-based research crafts stories and alternate worlds where agency and change take primacy over problems and harms faced by racialized students in STEM. This is important for interrupting damage-based narratives that continue to homogenize and subjugate racialized communities. We interpret students' recounted experiences of harms and discrimination to attend to the multiplicity of/in desires for alternate projects of world-

building around compassion, humility and belonging. We end with raising new ethical questions, tensions and contradictions that are inherent to our desires for analyzing data differently.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set
Assessment of Science Learning Through Technology
18-Mar-24, 3:45 PM-5:15 PM
Location: Directors Row E

Using Machine Learning to Predict the Productivity of Learning Trajectories in a Digitally Enhanced Classroom
Marcus Kubsch*, Freie Universität, Germany
Adrian Grimm, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Sebastian Gombert, DIPF, Germany
Nikol Rummel, Ruhr -Universität Bochum, Germany
Hendrik Drachsler, DIPF, Germany
Knut Neumann, IPN – Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
Digital technologies are widely considered a means to support the individualization of teaching and learning. The individualization of teaching and learning, however, requires tracking students' individual learning trajectories, recognizing unproductive learning trajectories, and taking respective instructional measures. Doing so is a serious challenge for teachers that digital technologies can help mitigate. As students are working with digital technologies, they produce both process (e.g., click streams) and diverse product data (e.g., written explanations, scientific models, or answers to exit tickets). Automated analysis of this data using machine learning (ML) allows for a just-in-time assessment of students' performance. Such just-in-time assessments of students' performance have successfully been used in the context of online learning environments to support students in mastering core scientific practices. So far it is unclear, however, to which extent it is possible to utilize data generated as students work with digital technologies in regular instruction – that is in a digitally enhanced classroom – to predict the productivity of learning trajectories and take respective actions. Here, we describe a study that investigated to what extent the productivity of students' learning trajectories can be predicted based on data gathered as students engaged in learning activities in a digitally enhanced science classroom.

Identification of Science Assessment Item Disengagement Through Analysis Using Psychophysiomeasurement
Richard Lamb*, East Carolina University, USA
Knut Neumann, IPN, Germany
Norah Almusharraf, Prince Sultan University, Saudi Arabia
Douglas Hoston, SUNY Buffalo State College, USA

ABSTRACT
For over a century, student achievement in science education has relied on standardized tests, which may not fully capture engagement and other aspects of student motivations and affect. Computer-based testing and physiological measures now allow exploring additional dimensions beyond selected answers. This study examines neurocognitive and physiological data's role in understanding item disengagement, stress, and cognitive demand during science content assessment. One-hundred fifth-grade students participated, and EDR/HRV and hemodynamics data were analyzed for response onset, sustained activity, and return to baseline. Low-stress events showed significant differences in average time to response onset, time to return to baseline, and sustained EDR response. Identifying rapid disengagement in item responses can improve score validity for educators and enhance adaptive features in CBT environments.

Assessing Student Errors in Experimentation Using Large Language Models: A Comparative Study with Human Raters
Arne Bewersdorff*, Technical University of Munich, Germany
Kathrin Seßler, Technical University of Munich, Germany
Armin Baur, University of Education Heidelberg, Germany
Enkelejda Kasneci, Technical University of Munich, Germany
Claudia Nerdel, Technical University of Munich, Germany

ABSTRACT
Identifying logical errors in complex, incomplete or even contradictory data like students' experimentation protocols is challenging. Recognizing the limitations of current evaluation methods, we investigate the potential of Large Language Models (LLMs) for identifying student errors. Our aim is to provide a foundation for productive, personalized feedback. Using a dataset of 65 student protocols, an LLM-based Artificial Intelligence (AI) system was developed and tested against human raters. Our results indicate varying levels of accuracy in error detection between the AI system and human raters. The AI system can accurately identify many fundamental student errors, for instance, the AI system identifies when a student is focusing the hypothesis not on the dependent variable but solely on an expected observation (acc. = 0.90), when a student modifies the trials in an ongoing investigation (acc. = 1), and whether a student is conducting valid test trials (acc. = 0.82) reliably. The identification of other, usually more complex errors, like whether a student conducts a valid control trial (acc. = .60), poses a greater challenge. This research explores the utility of AI in educational settings and contributes to the understanding of the capabilities of LLMs in error detection in inquiry-based learning like experimentation.

Assessment in Educational Makerspaces
Harmony Jones*, University of West Fl, USA
John Pecore*, University of West Fl, USA

ABSTRACT
Makerspaces are a tool that supports science education by providing a space and resources to foster project-based learning. Makerspaces reside in libraries, schools, educational

research sites, museums, and community spaces (Halverson & Sheridan, 2014). Existing research indicates numerous benefits for students engaging in maker-centered activities, including support for national educational programs like Common Core, STEM, and Next Generation Science Standards (NGSS) (Martin, 2015). Despite these promising indicators, there needs to be more systematic research on evaluating the crucial elements of an educational makerspace, namely the makers themselves, the available resources, and the activities conducted in the space. This study's multiple-case design explored how expert makerspace educators at the middle school level assess the people, resources, and activities within their makerspaces. The people, means, and activities (PMA) framework, developed by Hira and Hynes (2018), provided a structured approach to investigate the diverse aspects of makerspaces and three major components of the spaces. The findings from this multiple-case study can serve as valuable resources for school leaders interested in implementing maker-centered education and educators seeking to enhance existing programs. Ultimately, this study aims to contribute to the advancement of practice, policy, and research in the field of educational makerspaces.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set
Scientific Inquiry and Shifting Views
18-Mar-24, 3:45 PM-5:15 PM
Location: Plaza Court 1

Nature of Scientific Inquiry and Argument-Driven Inquiry: The Views of Pre-Service Teachers on Climate Change

Gülüzar EYMUR*, Giresun, Turkey
Sümeyye Erenler, Recep Tayyip Erdogan University, Turkey
Pınar Çetin, Bolu Abant İzzet Baysal University, Turkey

ABSTRACT
This study aimed to investigate how argument-driven inquiry (ADI) activities impact pre-service teachers' perceptions of the nature of scientific inquiry (NOSI), with a specific focus on climate change. In parallel with this aim an argument driven inquiry approach was used to teach climate change where the aspects nature of scientific inquiry was explicitly taught. A sample of 24 students participated a science project which includes ADI sessions that addressed climate change topics. Students participated in four ADI activities related to rising sea levels, clean water resources, extreme weather events, and zero energy building. The sessions incorporated explicit instruction on the nature of scientific inquiry to enhance students' understanding. A views of scientific inquiry (VOSI) questionnaire was used to investigate preservice teachers’ views of scientific inquiry before and after the instruction. The results of the study showed that preservice teachers developed in all six aspects of NOSI, but higher developments were observed in "Multiple methods of scientific investigations" and "Distinctions between data and evidence" aspects.

Analysing Students' Multimodal Representations of Nature of Scientific Practices and Scientific Methods

Kason Ka Ching Cheung*, University of Oxford, United Kingdom
Sibel Erduran, University of Oxford, United Kingdom
Alis Oancea, University of Oxford, United Kingdom

ABSTRACT

The aim of this paper is to present an analytical framework which characterizes students' multimodal representations of nature of scientific practices (NoSP) and scientific methods (NoSM). Previous ways of analysis mostly examined students' linguistic representation of NoSP/NoSM. However, these ways of analysis only uncovered part of their understanding, as students might represent NoSP/NoSM by diverse modes such as drawings. To explore the affordance of our framework, we developed a Multimodal Nature Of Science (MNOS) instrument to elicit fifty five seventh graders' responses of NoSP/NoSM before and after engaging in explicit-reflective instruction, yielding a total of 550 multimodal representations. The analytical framework developed was used to describe and categorise collectively a wide range of ideas about scientific practices and methods across domain-general and domain-specific contexts. These ideas changed after students engaged in NOS instruction that involved iterative composition of multimodal representations of NoSP/NoSM. Moreover, the framework also affords a detailed examination of a shift in semiotic resources of making meaning of NoSP/NoSM. Informed by the findings, we will discuss implications on curriculum and assessment of NoSP/NoSM.

Clarifying Vision 1.5: The Essence of Science

Judith Lederman*, Illinois Institute of Technology, USA
Valarie Akerson, Indiana University, USA
Selina Bartels, Valparaiso University, USA
Renee Schwartz, Georgia State University, USA

ABSTRACT

This paper examines the construct of scientific literacy and offers a reconceptualized Vision 1.5 as the Essence of Science. Knowledge about scientific inquiry, nature of scientific knowledge, and scientific reasoning are essential knowledge domains for developing functional and multidimensional scientific literacy. Despite being the primary goal of science education, scientific literacy remains elusive to the general citizenry. Further, there remains mistrust and misunderstandings about science, including recommendations for sustainability and health that impact everyone. Teachers struggle to teach these concepts in an integrated manner that also targets science content knowledge and prepares learners to understand and evaluate scientific issues necessary to make informed decisions. In an effort to facilitate pedagogical knowledge and practices necessary to achieve scientific literacy, we present Vision 1.5, the Essence of Science, as an overarching framework of what science is and what scientists do. This vision looks to define and unify the aspects of EoS as a comprehensive construct which will result in better classroom application as well as a more literate citizenry.

"It's what I have always been taught." Undergraduate Science Students' Views about Scientific Inquiry

Renee Schwartz*, Georgia State University, USA
Heidi Turcotte, Georgia State University, USA
Aihanh Maasen, Georgia State University, USA

ABSTRACT

Scientific Inquiry Literacy [SIL], first introduced in 2023, includes knowledge of nature of scientific inquiry [NOSI] that enables individuals to recognize how scientific claims are validated and evaluated with evidence and reasoning. Such knowledge is necessary as citizens grapple with making sense of, and decisions toward, scientific issues in today's world. This study follows a series of international studies that show learners in primary and secondary schools have poor understandings of NOSI. Our purpose was to examine NOSI views held by postsecondary students majoring in a science or science-related field. These are adults whose role in society becomes increasingly significant as they progress through higher education and into their STEM careers. Are they prepared to make informed decisions that impact their health and the health of the environment? Have they achieved SIL? The results suggest little progress is being made. Participants held the most naïve views regarding "multiple methods," "same procedures may not yield same results," and "data and evidence are not the same." They were most informed about "procedures are guided by questions asked." Differences were found based on university major and gender. This study is a starting point for understanding the needs of undergraduates for fostering SIL.

Strand 14: Environmental Education and Sustainability

SC-Organized Paper Set

Climate Justice in Science Education

18-Mar-24, 3:45 PM-5:15 PM

Location: Directors Row J

Assessing the First Year of the Environmental Justice STEMM Leadership Academy

Rachel Gisewhite*, University of Southern Mississippi, USA
Jennifer Walker, University of Southern Mississippi, USA
David Holt, University of Southern Mississippi, USA

ABSTRACT

University researchers and community partners in a Gulf South region created an academy for leadership in environmental justice (EJ) and STEM as an after-school, community-driven STEMM leadership program seeking to engage 6-12th graders in authentic scientific inquiry designed considering regional environmental justice issues. The Academy uses learning through hands-on citizen science activities that serve the immediate interests of BIPOC communities in the Gulf South to encourage the students' appreciation of why EJ is important to frontline BIPOC communities in the region. The Academy also introduces leadership skills and region-specific STEM career tracks that may inspire local youth activism or interest in STEM careers. The first year of the Academy was centered on urban heat island

mapping and included learning to use scientific tools, various short- and long-term weather-related experiments, and reading related literature. This presentation will discuss the successes, challenges, and opportunities in the creation and first year of the Academy and the initial results from this mixed methods study. The analysis shows increased interest in STEM and awareness of EJ issues in their communities but gaps in STEM knowledge to execute EJ solutions. The presentation explores and elaborates on educational implications and steps for future progress.

The Current State of Climate Justice-Related Research in Science Education and Its Implications

Hong Tran*, University of Georgia, USA
Emily Adah Miller, University of Georgia, USA
Ajay Sharma, University of Georgia, USA
Shweta Lahiri, University of Georgia, USA
Julie Luft, University of Georgia, USA
Joseph DeLuca, University of Georgia, USA
Elizabeth French, University of Georgia, USA

ABSTRACT

This literature review systematically reports on 36 articles regarding climate justice-related research in science education. The articles were selected from seven leading science education journals and a specific journal dedicated to environmental education. A priori and emic coding followed by thematic analysis led to six themes: (1) climate justice-related research in science education is relatively new and expanding, (2) some researchers were concerned about the lack of awareness of broader community solutions, (3) emotion and hope played an important role in climate justice-related lessons, (4) climate justice-related lessons were offered mainly for secondary students, (5) there were several instructional practices for designing climate justice lessons, and (6) there was a need for science teachers to be prepared to navigate social justice in their teaching. The findings show that there is a lot that needs to be done to promote learning about and engaging in climate justice. Moreover, climate justice instruction requires some adjustments not only in science teaching but also in the transposition of power in educational systems.

Community Organizing for Climate Change and Environmental Justice Instruction at the School District Level

Helen Fitzmaurice*, UC Berkeley, USA
Michelle Hoda Wilkerson, UC Berkeley, USA

ABSTRACT

Climate change and environmental justice education (CCEJE) is perhaps the most urgent example of "science for the rest of us" to face our world this century. Despite the urgent need for CCEJE, the fact that 78% of US parents say that it should be taught in schools (Chekis et. al, 2018), and despite increasing inclusion of CCEJE in science standards (e.g. NGSS, 2014) and across content areas (e.g., New Jersey, CA EP&Cs), the implementation of CCEJE in the classroom is ad hoc even in secondary science classrooms (Plutzer et. al, 2016). In response to

this gap, ecosystems of actors: teachers, students, parents, and other community members in districts across the country are organizing to bring climate change and environmental justice into classrooms at scale across their school districts. In this paper, we examine how these various actors work together to push for the systematic (rather than ad hoc) implementation of climate change pedagogy across their schools or districts through a multiple case study approach of four districts on the West Coast of the United States.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set
Collective Learning as a Solution to Envrionmental Challenges
18-Mar-24, 3:45 PM-5:15 PM
Location: Directors Row I

Evaluating Biological Accuracy and Problem-Solving Utility: Biomimicry Frameworks for Interdisciplinary Innovation and Education
Dimitri Smirnoff*, University of Minnesota, USA
Anita Schuchardt, University of Minnesota, USA
Gillian Roehrig, University of Minnesota, USA
Emilie Snell-Rood, University of Minnesota, USA

ABSTRACT
The natural world is increasingly seen as a source of inspiration for sustainable solutions to socio-environmental challenges. Integrated STEM curricula seek to address real-world problems and integrate across disciplines; however, they struggle to meaningfully incorporate the life sciences with engineering practices. To address the difficulty of tapping into biological knowledge, frameworks distilling biology into accessible statements have been developed to educate and inspire engineering professionals and 6-16 grade students. However, the accuracy and utility of these frameworks have not been systematically assessed. This research surveyed people from different professional backgrounds and career stages to assess their perception of the biological accuracy and problem-solving utility of the different frameworks used in bio-inspired design. Differences in perceptions emerged between biologists and non-biologists, and among biology professionals and biology undergraduates. Notably, non-biologists rated statements as more accurate than biology professionals, suggesting current frameworks may foster biological misconceptions. Simultaneously, specific statements were rated as more useful for inspiring designs by non-biologists. This study forms a foundation for exploring factors that enhance statement biological accuracy and relevance in bioinspired design. Ultimately, our work contributes to accessible biology education for practitioners and as well as students from middle school to college.

Education for Sustainable Development through Socioscientific Issues: Pre-service Teachers' Pedagogical Design Capacity
Tuba Stouthart*, Eindhoven University of Technology, Netherlands
Dury Bayram, Eindhoven University of Technology, Netherlands

Jan van der Veen, Eindhoven University of Technology, Netherlands

ABSTRACT
Even though the importance of sustainability has been recognized in education, teachers struggle with identifying an appropriate method to implement education for sustainable development (ESD) in STEM subjects. There is a relatively large literature on ESD, and the implementation of socioscientific issues (SSI) separately. However, there is limited research on using SSI for ESD. For this reason, this empirical study aims at characterizing STEM teacher candidates' pedagogical design capacity (PDC) to address what resources they use, and how they interact with these resources to design SSI-based instruction to facilitate ESD. The qualitative data is collected through field notes, reflection reports and semi-structured interviews. The results reveal that during their design, pre-service teachers referred to teacher resourcesthe most, followed by collaborative resources, and instructional resources. Even though their use of resources shows strong connections between SSI and their pedagogical content knowledge, pre-service teachers' consideration regarding assessment remains inadequate. Furthermore, this study shows that professional development sessions have the potential to foster pre-service teachers' use of PDC resources to address ESD.

Exploring Collective Learning in an Environmental Movement in India using the Community of Practice Framework

Aparajita Rajwade*, North Carolina State University, USA
K.C. Busch, North Carolina State University, USA

ABSTRACT
This research study employed the Community of Practice (CoP) framework to examine the social learning and interactions that occurred among citizens engaged in an environmental movement in India. The research questions focused on the manifestation of the dimensions of CoP (joint enterprise, mutual engagement, and shared repertoire) within the movement. A qualitative case study design was employed, by conducting thematic analysis of interviews. Preliminary analysis reveals shared purpose, mutual engagement, and a shared repertoire among the members. Findings also underscore the importance of a sense of obligation among the members and reveal motivations rooted in member's biospheric and altruistic values. This research contributes to environmental education discourse, offering insights into informal settings and diverse contexts. Applying a CoP framework, this study demonstrates how collective learning manifests within a movement, shedding light on intellectual efforts driving such endeavors. Additionally, the study explored the potential implications for environmental education and the teaching and learning of science.

Exploring Narratives as a Tool for Fostering Transformation Toward Sustainability Through Science Education

Giulia Tasquier*, University of Bologna, Italy
Erik Knain, University of Oslo, Norway
Alfredo Jornet, University of Gerona, Spain
Hanna Rokenes, University of Oslo, Norway

ABSTRACT
We are facing changes of epochal significance and despite the growing attention from many corners, science at school still seems to fail in being supportive for students' making sense of these demanding socio-scientific questions. In the context of such complex problems as today's sustainability and climate change challenges, narratives become a primary and crucial means for integrating scientific knowledge relevant to science, authentic inquiry and critical thinking skills needed to pursue solutions drawing from science, and the goal-oriented, affective and active engagement in actual action. Thanks to micro-narratives, the young can have the opportunity to figure out who they are and envision plausible futures for themselves and their surroundings through making use of cultural resources in social relationships with the people who take part in these worlds. However, to what extent narratives can also provide insights into the current attitudes of young people about their sense of agency in relation to climate change and sustainability challenges? This study aims to answer this question by analysing students' narratives collected through a SenseMaker questionnaire based on sustainability stories.

Poster Session A
18-Mar-24, 5:30 PM-6:15 PM
Location: Plaza Foyer

Strand 1: Science Learning: Development of student understanding
Argumentation in Elementary School, from Evidence and Models
Roger Tobin*, Tufts University, USA
Sara Lacy, TERC, USA
Sally Crissman, TERC, USA

ABSTRACT
Researchers have long recognized that scientific argumentation can and usually does involve claims grounded in models as well as those based directly on evidence. The NGSS framing of practices, however, and much literature on argumentation, prioritizes the role of empirical evidence. We argue that this is too limited a view of how scientists work, and that both model-based and evidence-based claims can and should have a place in classroom science argumentation and explanation. We provide and examine examples of elementary school students engaging in productive scientific reasoning and argumentation about energy that draws both on evidence from direct observation and on agreed-upon principles of their preliminary model of energy. These examples show that even young children are able to understand and negotiate the delicate interplay between evidence and models in seeking to arrive at scientific explanations.

Strand 1: Science Learning: Development of student understanding
What Predicts Scientific Literacy: Revealing Influential Factors and Group Comparisons via a Machine Learning Model
Hyesun You*, The University of Iowa, USA
Minju Hong, University of Arkansas, USA

Li Zhu, The University of Iowa, USA
Zhenhan Fang, The University of Iowa, USA

ABSTRACT
Many scholars have traditionally examined characteristics and features linked to students' science performance using classical methods. However, there is a dearth of research on predicting student achievement using machine learning models in science education. The aim of the present study is to address this gap by using the 2006 and 2015 Programme for International Student Assessment datasets to construct a prediction model for students' scientific literacy. We used training sets, accounting for 80% of the entire dataset and a test set, comprising the remaining 20%. Subsequently, we applied the XGBoost model to each of the four training sets and fitted the model to the test dataset. For the overall group, socioeconomic status was the most significant predictor of science performance, followed by self-perceived scientific literacy. For the low and mid-high performance groups, the two variables were top-ranked variables as well. The type of school and gender were the least important variables to predict science performance. The grade, science practices, and motivation showed slightly different results. The ML model provides valuable insight into predictors' significance that influence academic outcomes, enhancing both accuracy and reliability. This could empower researchers and policymakers by laying a foundation for the positive transformation of educational initiatives.

Strand 1: Science Learning: Development of student understanding

Challenges in Latent Variables Test Development based on the concept of Energy

Lauri Kõlamets*, The University of Tartu, Estonia
Heili Kasuk, University of Tartu, Estonia
Jack Holbrook, University of Tartu, Estonia
Rachel Mamlok-Naaman, Weizmann Institute of science, Israel

ABSTRACT
Energy conservation and the change of energy from one form to another are key concepts in everyday life. Energy concept is characterized in science education with four main components: energy as a source-form, transferable or undergoing transformation, degradable or capable of dissipation, and being conservable. One way to measure student attained curriculum outcomes in conceptualization of the energy concept (CEC) is to use non-direct psychometric measurements based on items under latent variables. For developing a CEC test, this study undertook a two-stage process, while focusing on quality of each item and latent variables. The base to describe increasing cognitive complexity, was on the 1st stage test model done with the SOLO (Structure of Observed Learning Outcomes) taxonomy, while 2nd stage model was supported with TIMSS (Trends in International Mathematics and Science Study) 2019 Framework. This study includes results from 16 and 31 multiple-choice test items administered in 2022 (n = 153) and 2023 (n = 158) with grade 9 students in Estonia. Rasch analysis provided the quality of developed items and test reliability. Results largely supported a TIMSS 2019 Framework model test, which focused instead of all four energy concept components mostly on energy transfer and transformation.

Strand 1: Science Learning: Development of student understanding

Post-Secondary Students' Concepts of Elasticity: The Iron and Rubber Dilemma

Md Nazmuzzaman Shifat*, Harvard University, USA
S M Hafizur Rahman, University of Dhaka, Bangladesh

ABSTRACT

The concepts students hold on different topics are not always aligned to scientifically accepted notions in that area. When students do not have scientific concepts due to lack of knowledge or have alternative concepts, further development of their conceptual understanding is hindered. This study investigated post-secondary students' concepts of elasticity following an explanatory sequential mixed methods design. In the first phase, data were collected from 100 undergraduate students from five faculties with a semi structured questionnaire. Quota sampling was used to select students. In the second phase, 12 students were selected purposively for two FGDs to further explore their concepts and sources of these concepts. Quantitative data from the first phase were analyzed using descriptive analysis and thematic analysis was used for qualitative data obtained in the second phase of the study. The findings reveal that students do not have same understanding of elasticity. Students have Scientific Conceptions (SC), Lack of Knowledge (LK) and Alternative Conceptions (AC). Moreover, the pattern of these concepts is similar in students regardless of their current course of studies and gender. Two major sources of these non-scientific concepts are daily life use of the word and textbooks.

Strand 1: Science Learning: Development of student understanding

From Anxiety to Empowerment: The Role of Error Beliefs in Mathematics Learning

Xingfeiyue Liu*, The Ohio State University, USA
Eric Anderman, The Ohio State University, USA
Lynley Anderman, The Ohio State University, USA
Tzu-Jung Lin, The Ohio State University, USA
Michael Glassman, The Ohio State University, USA

ABSTRACT

This study focused on middle school students' attitudes toward errors in mathematics and their adaptive responses, investigating their associations with various affective-motivation constructs. The overarching goal was to understand how students' beliefs and adaptivity to errors relate to their lives. Guided by the achievement goal theory, structural equation modeling was employed to explore the links between students' error-related beliefs, adaptive responses, perceived goal structures, math self-concept, and math anxiety. Findings revealed that both mastery and performance-approach goal structures positively correlated with adaptive error beliefs and reactions. Additionally, adaptive error responses acted as a protective factor, influencing positive academic self-concept in math and reducing learning anxiety. This study underscores the significance of cultivating positive beliefs and adaptive responses to errors in mathematics education.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Media and Information in Science Lessons: An Analysis of Discursive Interactions in a Brazilian Classroom

Ludmila Kelles, Universidade Federal de Minas Gerais, Brazil
Nathan Lima, Universidade Federal do Rio GRande do Sul, Brazil
Luiz Franco*, Universidade Federal de Minas Gerais, Brazil

ABSTRACT

In this study we investigate how High School students discursively constructed relationships between science and media over Biology lessons. We followed a 1st year high school classroom over the course of the academic year in 2021. Based on ethnographic perspective on education, we selected events in which misinformation was a central part of students' discussions. The events were transcribed word by word and the analysis was guided by Bakhtinian proposal on reflection/refraction of language. The results indicated different interpretations by students about the relationship between media and science. We found events in which the media was interpreted as an agent capable of refracting or reflecting scientific information. Regarding the use of sources, the students started from more restricted analyses, relying on arguments from authority, to more complex verifications that included: i) assessing the credibility of sources, ii) analysing the features of the language and iii) considering possible conflicts of interest. This change did not happen linearly, but correlated to teacher's questions. We discuss the role of science education in contexts of misinformation.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Teaching and Learning Sequences on the Floating and Sinking Phenomenon: An Evidence-Based Comparison

Francisco Castillo Hernández*, University of Groningen, Netherlands
María Jiménez-Liso, University of Almería, Spain
Digna Couso, Autonomous University of Barcelona, Spain

ABSTRACT

The tasks prior to designing teaching and learning sequences traditionally involve reviewing didactic literature and conceptual clarification. Comparing TLSs on specific topics is common in teachers' daily work, but it is not considered a pre-design task in didactic literature. In this research, we try to fill the gap in the scientific literature by comparing five TLSs, in such a way that we recognise its importance and systematise a common procedure among teachers. We propose a documentary analysis of these TLSs. Results highlight the impact of conceptual treatment and teaching approaches when designing TLSs on floating and sinking phenomenon: if the phenomenon is approached through density and inquiry-based teaching without modelling intention, a large number of testing objects are used and hands-on tasks are set, where descriptive knowledge is constructed. On the other hand, if flotation is approached through the force model and the teaching by modelling-based approach (and its combination with inquiry), the number of testing objects decreases drastically and, in

addition to the hands-on tasks, other tasks of more modelling nature (minds-on) are also set in order to build the model that allows them to explain and predict situations about flotation.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

A Dual Case Study of Science Teachers' who Implemented Self-Regulated Learning in their Classrooms

Boaz Hadas*, Faculty of Education in Science and Technology, Technion, Israel
Avivit Arvatz, Faculty of Education in Science and Technology, Technion, Israel
Rotem Waitzman, Charles E. Smith High School for the Arts, Israel
Yehudit Dori, Faculty of Education in Science and Technology, Technion, Israel

ABSTRACT

As education systems face the growing demand for autonomous learners, the need for teachers' abilities to demonstrate self-regulated learning and teaching (SRL&T) intensifies. Research on training processes of teachers as mentors for self-regulated learning (SRL) with a focus on teachers' SRL&T practice in the schools has been scant. We aim to identify and examine the teachers' SRL&T and their students' SRL in the context of the personal, classroom, professional, and school ecologies. The dual case study we present involved two science teachers and 101 of their 10th to 12th-grade students. Interviews with the teachers, online tasks developed by the teachers for their students, and reflections were analyzed to extract themes related to the different interactions with the ecosystems. A specially developed rubric helped determine the teachers' knowledge type levels, as expressed in the online tasks, and the teachers' and students' reflection levels. The results show a parallel development in the teachers' SRL&T levels and students' reflections. Teachers' ability to implement SRL depended on catalysts such as their perception of SRL, autonomy, and degrees of freedom in their schools. The contributions are both theoretical, relating to the implementation of SRL, and methodological, including novel analytical approaches.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Embodied Cognition: Unknown by Teachers but Used Surprisingly Often in Class

André Meyer*, Leibniz University Hannover, Germany
Gunnar Friege, Leibniz University Hannover, Germany

ABSTRACT

Since the mid-1990s, a number of interdisciplinary theories have been discussed in the cognitive sciences, psychology and philosophy, which are intended to explain how body and mind are linked. Often the term Embodied Cognition is used as a generic term for such theories. In addition to theoretical discussions, isolated empirical studies are being conducted to investigate the implications for teaching-learning processes by examining the influence of body movements on learning outcomes. However, a large area of research has not yet developed from this, leading to the assumption that the findings on Embodied Cognition are not yet used in everyday teaching.

For this reason, an explorative interview study was conducted to examine the significance of Embodied Cognition in physics teaching. Fourteen teachers from different types of schools were asked what theoretical knowledge they have about the various embodiment theses and whether they use their students' bodies in physics lessons.
A qualitative content analysis shows that the theories of the Embodied Cognition are unknown by teachers, but all of them use movements in physics classes to support learning. It is particularly noticeable that only a few methods are widely used, whereas a large number of other methods are used only very sporadically.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

A Systematic Literature Review of Teaching Approaches in Advanced Placement Science Courses

Robin Bulleri*, North Carolina State University, USA
Soonhye Park, North Carolina State University, USA

ABSTRACT

The Advanced Placement (AP) program has experienced rapid increase in enrollment in the past ten years. However, little is known about how teachers instruct their classes, or which instructional strategies impact student learning. The purpose of this study was to characterize instructional strategies utilized in AP science courses, and to identify those instructional strategies that are supported by empirical evidence to positively impact student learning. Study inclusion criteria consisted of empirical articles aligned with the research questions, published in a scholarly journal within the last ten years in English, and addressed instruction in Advanced Placement science classes in high school. Thematic analysis was used to identify patterns in instructional strategies. Emerging themes were categorized into three groups: diverse learners, inquiry, or other considerations. Very few included articles examined the instructional practices supported by empirical evidence as having positive impacts on student learning, leaving a noteworthy gap in the literature. Recommendations for future research include empirical research to determine which instructional strategies improve student outcomes. Further examination of instructional strategies and their impact on student learning would inform science instruction, teacher training, and professional development.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Factors Affecting Science Teaching in STEM: A Systematic Review

Heba EL-Deghaidy*, American University in Cairo, Egypt
Zahrah Almasabi, Najran University, Saudi Arabia
Hamdan Alamri, King Saud University, Saudi Arabia
Maha Albogami, King Saud University, Saudi Arabia
Nidhal Alahmad, King Saud University, Saudi Arabia
Saeed Alshamrani, King Saud University, Saudi Arabia
Abdo Almufti, King Saud University, Saudi Arabia
Nasser Mansour, Qatar University, Qatar

Abdulaziz Alfayez, King Saud University, Saudi Arabia
Fahad Alshaya, King Saud University, Saudi Arabia

ABSTRACT
This systematic review examines the teaching practices by science teachers in implementing STEM activities, as well as the internal and external contextual factors affecting such practices. The review employed PRISMA guidelines, and 32 English empirical studies published between 2018 and 2022 in the Web of Science databases were analysed through thematic analysis. Results highlight the evolution of roles and practices of science teachers within STEM contexts, with a greater focus on instruction over the learning environment. The review identifies the nature, level, and role of integrated STEM disciplines, particularly within the NGSS framework. Internal factors like teachers' attitudes, self-efficacy, beliefs, and anxiety, as well as pedagogical and disciplinary knowledge, affect teaching practices. External factors, including teacher education programs, professional development, and implementation aspects, were also identified. The review emphasises the importance of high-level country visions, funded agencies, and supportive schools in shaping STEM education's future, alongside higher education institutions' efforts. Hindering factors include insufficient curricular focus on STEM integration, limited collaborative planning time, school culture, professional community formation, and external partnerships. A comprehensive conceptual framework is proposed to map interconnected relationships in the STEM ecosystem, shaping student learning outcomes through an intricate interplay of internal and external factors.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Iterative Modeling of Earth's Interior for Conceptual Change in Middle School Earth Science

Melissa Olson*, Texas Tech Univeristy, USA
Jocelyn Miller, Texas Tech Univeristy, USA
Gina Childers, Texas Tech Univeristy, USA
Kristie Gutierrez, Old Dominion University, USA
Jin Kyeong Jung, Texas Tech Univeristy, USA

ABSTRACT
Students have prior knowledge of scientific concepts that influence and create alternate conceptions of scientific phenomena. Science education strives to move students' alternate conceptions to be aligned with scientific conceptions. This study focuses on a learning unit in a 6th grade Earth Science classroom (n=89) centered on plate tectonics and the Earth's interior that explores the use of iterative modeling for visualizing student learning and tracking conceptual change throughout the unit. At the beginning of the unit, students depicted their thoughts on Earth's interior structure with a modeling activity. The students then revised the model during the middle of the unit and at the end of the unit. The models were coded based on the similarity to the scientifically accepted structure of Earth's interior. Students showed significant ($p<0.001$) improvement from the beginning of the unit to the end of the unit in the alignment of their models to the scientific conception. This study indicates modeling could be a tool for the identification of alternate conceptions as well as a formative assessment to track learning and guide instruction.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Exploring the Impacts of Educative Model-Based Biology Instructional Materials on Teacher Outcomes

Cari Herrmann Abell*, BSCS Science Learning, USA
Jeffrey Snowden, BSCS Science Learning, USA
Molly Stuhlsatz, BSCS Science Learning, USA
Brian Donovan, BSCS Science Learning, USA
Cynthia Passmore, UC Davis School of Education, USA
Christopher Wilson, BSCS Science Learning, USA

ABSTRACT

With the implementation of the multidimensional Next Generation Science Standards, educative instructional materials play a critical role in supporting shifts in instructional practice toward scaffolding students' multidimensional sensemaking. This study seeks to explore the impact of educative instructional materials in the context of high school biology that support teachers in understanding model-based reasoning as an approach to support students in developing an integrated, multidimensional understanding of science. We conducted a quasi-experimental study with 48 teachers. The treatment group received five days of online professional development and implemented the model-based reasoning materials. The comparison group used their business-as-usual materials. Rasch and linear regression models were used to evaluate the impact of the materials on three teacher outcomes. We found a moderate effect on teachers' science content knowledge, but we did not find an effect on teachers' confidence in teaching science or teachers' vision of effective science teaching. Because ambiguity is inherent in a model-based reasoning approach, we explored whether teachers' need for closure moderated the impact on their content knowledge. However, the model showed no significant moderation. Our findings suggest that using educative biology instructional materials positively impacts high school teachers' content knowledge about model-based reasoning in biology.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Pragmatic Model Building: A 4D Socially Enacted Understanding of Celestial Mechanics

Michael Leary*, University of Georgia, USA

ABSTRACT

3D modeling is known to be difficult, especially at the introductory level where generally 2D models are preferred to be generalized, especially in a mathematical sense in an introductory physics or astronomy class. It is not an elementary jump from 2D to 3D by just "adding" in another dimension as there is an interplay between the dimensions making it a known complexity. Embodied modeling may help introductory students better understand the real-world 3D environments that are inherent in nature. If one is to truly understand processes in nature, the third dimension and time-dependent motions cannot be ignored, especially in classes such as physics and astronomy. The author wishes to report on a 3D-time-dependent

intervention/lab which shows promise in helping student better understand the complex nature of processes in our universe. The intervention took an embodied approach utilizing time-sequence stop-motion steps to assist the students with an iterative modeling procedure that was then mapped to the Lagrangian describing the system. This lab was performed with high school students and showed an ability to assist with overcoming many misconceptions revolving around celestial mechanics.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Data Fluency Landscape Analysis: Identifying Strengths, Needs, and Resources for Data-Rich Instruction in Earth Science

Nicole Wong*, WestEd, USA
Rasha Elsayed, WestEd, USA
Kirsten Daehler*, WestEd, USA
Katy Nilsen, WestEd, USA
Svetlana Darche, WestEd, USA

ABSTRACT

Data fluency – the ability and confidence to actively make sense of and use data – is key to students' successful participation in everyday decision-making and informed engagement with their communities. This paper contributes to members of the National Association for Research in Science Teaching (NARST) and the education community at large because it helps to define the needs in a newly-emerging space in K–12 education: data fluency. We share findings from a mixed-methods landscape analysis (online survey and focus group interviews) conducted with 156 secondary science educators to identify their existing assets, roadblocks, and supports needed for data-rich instruction. We carried out a descriptive analysis of all closed-ended survey items, as well as coded and summarized all open-ended survey items and focus group interview responses. While educators and their students already bring data skill, technological resources, and cultural knowledge to teaching and learning, educators indicated that they would benefit from having more classroom-ready datasets, support for using a wider range of data visualization tools, professional learning that supports instruction around the data investigative process, and strategies that promote student discourse and student-centered learning with data.

Strand 5: College Science Teaching and Learning (Grades 13-20)

Impact of a Forum for Chemistry and Math Introductory Course Instructors – a Professional Development Model.

Oluwatobi Odeleye*, West Virginia University, USA

ABSTRACT

Students enter college with a lot of excitement about STEM fields, but they tend to lose interest over the first two years, which is when they typically enroll in large-enrollment courses (LECs) (Harris et al., 2020). Among those courses, introductory chemistry courses are usually associated with unpleasant experiences and are considered to diminish students' enthusiasm toward STEM fields (Marsh et al. 2004; Tai et al. 2022; Shah et al., 2021). However,

research has also shown that engaging students in the learning process in a classroom improves retention, thus we proposed a forum centered around improving engagement in LECs (Hall et al. 2013; Berger et al. 1999). This forum was geared towards chemistry LECs instructors with the goal of equipping them with basic knowledge and tools in education research, specifically for crafting research questions and processing data to help them assess engagement tools used in their courses. Math educators were also a part of the forum as research has shown a strong correlation between math ability and chemistry success (Chen et al. 2018). This study describes the process of implementing the forum as well as the participants' perceptions of the effectiveness of the model.

Strand 5: College Science Teaching and Learning (Grades 13-20)

Examining Students' Peer-to-Peer Questions During an In-Class Collaborative Activity: Trends and Outcomes.

James Nyachwaya*, North Dakota State University, USA
Soren Miller, St. Olaf College, USA
Tarah Dahl, North Dakota State University, USA
Krystal Grieger, North Dakota State University, USA

ABSTRACT

Reforms in science education have called for engaging STEM students in science and engineering practices. One of the practices involves asking questions. In this study, we report findings from research looking at General Chemistry (II) students' peer-to-peer questions. We looked at the frequency of questions asked, the nature of the questions, and which prompts elicited the most questions. Further, we classified questions used Blooms taxonomy to determine the levels of questions asked. Our results show that on average, students asked each other 15 questions per group. The peer-to-peer questions fell into the social, process and content categories. The prompts that asked students to predict and sketch (create) elicited the highest number of content questions, and these were the prompts most students struggled to answer correctly. Most of the content questions asked were at the knowledge or remembering level of Bloom's taxonomy. Questions played a number of roles during the activity, including initiating and sustaining discussions, eliciting additional ideas from group members, challenging ideas raised by others and promoting social metacognition.

Strand 6: Science Learning in Informal Contexts

Community Dimensions of STEM Learning at Science Fiction Conventions: Communities of Practice & Modes of Belonging

Rebecca Hite*, Texas Tech University, USA
Gina Childers*, Texas Tech University, USA
Kania Greer, Georgia Southern University, USA
Samanthia Noble, Texas Tech University, USA
Olivia Kuper, Texas Tech University, USA

ABSTRACT

Communities of Practice (CoP; comprised of joint enterprise, mutual engagement, and shared repertoire) is one model to explore how social communities facilitate learning via (legitimate peripheral) participation. However, the CoP model is limited in describing how learning is occurring through participants' sense of belonging to the CoP, especially if that CoP is a smaller part of a larger CoP. Modes of Belonging (MoB; comprised of engagement, imagination, and alignment) provide a means to further qualify individuals' levels of participation vis-à-vis the social learning within the CoP. Together, CoP and MoB interlay to create Wegner's (2000) Community Dimension model, or the ability to model how activities within sub-CoPs relate to larger communities of practice and learning. In the present study, 13 individuals attending the Dragon Con Science Fiction (SciFi) convention were interviewed about their experiences learning STEM at optional 'science-fact' tracks. Data was coded by CoP and MoB constructs. Findings suggest a CoP of celebrating mutual interests in STEM, enjoyment, collaboration, and inclusivity and a MoB that promoted egalitarian views of science knowledge, communal access to STEM and STEM professionals, and specific norms for community participation. Future use of community dimensions and Wegner's (2000) identity framework are discussed.

Strand 6: Science Learning in Informal Contexts

Belonging in Science: Perspectives from High School Students

Linda Morell*, University of California, USA

ABSTRACT

Belonging is a fundamental human need and has been studied extensively in some contexts. Yet, little is known about interventions, including those in informal science, that promote belonging, and even less is known about belonging in science in these contexts. In addition, although "belonging" is reported in many studies, there is little to no consensus about how belonging should be conceptualized and measured. In this study, eight high school students enrolled in an informal science program and living in a large, diverse, urban school district in the United States participated in exploratory interviews to provide information about what belonging means to them. Results indicate that students have a clear but nuanced understanding of sense of belonging (in general) and of belonging in science. Responses yielded a complexity of feelings (such as feeling welcome, comfortable, included, connected, represented, and supported) and structures (such as being a part of a community of like-minded individuals and getting support from knowledgeable adults). Using ideas generated from high school students in this way along with using existing ideas about belonging holds great promise for use in future studies to extend and conceptualize a data-informed construct of belonging in science for high school students.

Strand 7: Pre-service Science Teacher Education

Reevaluating FOCIS Survey with Pre-service Elementary Teachers: CFA on Latent Constructs of Discovering and Making

Lillian Bentley*, University of Virginia, USA
Xin Xia, University of Virginia, USA

ABSTRACT

The FOCIS (Framework for Observing and Categorizing Instructional Strategies) survey was developed to understand the types of science activities (discovering, making, performing,

competing, collaborating, teaching, and caretaking) that students enjoy (Tai et al. 2021). This research project tested the validity of discovering and making with pre-service elementary teachers. We tested three models using Confirmatory Factor Analysis (CFA) and ran fit statistics with a robust mean squared error of approximation (RMSEA), Standardized Root Mean Squared Residual (SRMR), and Comparative Fit Index (CFI). The best fitting model showed that CFI=0.979, SRMR=0.042 RMSEA = 0.079. Our analysis concluded that the constructs of discovering and making were well aligned. However, the two structures for pre-service teachers should be one latent construct.

Strand 7: Pre-service Science Teacher Education

Making Space for Repertoires, Community Resources, and Sensemaking with Elementary Science Teacher Candidates

Mutiara Syifa*, The Ohio State University, USA
Ashlyn Pierson*, The Ohio State University, USA
Sophia Jeong*, The Ohio State University, USA
Andrea Henrie*, The Ohio State University, USA

ABSTRACT

Facilitating equitable-sense making requires teachers to notice classroom inputs or contextual factors (i.e., students' resources, external resources, and teachers' resources). However, emerging teachers such as teacher candidates are prone to notice students' behavior, thereby affecting their noticing of sense-making moments. This study focuses on teacher candidates' (TCs) noticing classroom inputs to promote equitable sense-making. The authors questioned: in what ways in what ways do teacher candidates (TCs) notice their classroom inputs for possible equitable sense-making instruction? The authors draw from Haverly et al.'s (2020) equitable sense-making framework to analyze the data collected from elementary science methods courses at two US universities. TCs' noticing encompassed students' repertoires, local communities, and TCs' reflections that may entail their future teaching. The findings emphasize the TCs' need for intentional support in navigating sense-making and fostering equitable instruction. The study contributes to understanding how TCs notice and interpret classroom inputs for possible equitable teaching, urging a shift toward equity-oriented approaches. Lastly, this study prompts science educators to provide continuous assistance, promoting equity that acknowledges diverse student identities.

Strand 7: Pre-service Science Teacher Education

Effect of Teacher Preparation Program on Science Teachers' Use of Academic Language Development Strategies

Rachel Benzoni*, University of Nebraska-Lincoln, USA
Elizabeth Lewis, University of Nebraska-Lincoln, USA

ABSTRACT

English learners (ELs) remain underrepresented in STEM coursework and STEM fields (NCES, 2022), despite being one of the fastest-growing student populations (Pew, 2018). Simultaneously, standards and requirements for success in science have shifted significantly, making it imperative that teachers implement research-backed instructional interventions which support academic language development and science learning. Nevertheless, many teacher preparation programs do not require teacher candidates to complete coursework preparing them to support their EL students' linguistic assets in the science classroom. This study analyzed the effect of two teacher preparation program designs on the usage of academic language development (ALD) strategies for science teachers at two different phases of teaching experience. Researchers rated participating teachers on their use of ALD strategies using the Discourse in Inquiry Science Classroom (DiISC) instrument. Teachers who completed the graduate teacher preparation program, regardless of their teaching experience, were rated significantly higher in their ALD strategy use than those who had completed the undergraduate program. The results add weight to the argument for teacher preparation programs to include at least one course in EL-specific pedagogical practices.

Strand 7: Pre-service Science Teacher Education

Pre-Service Teachers' Orientations to the Role of Student Thinking in Instruction across the Two-Worlds Pitfall

Ryan Coker*, Florida State University, USA
Lama Jaber, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT

For teacher educators, there are significant challenges in supporting pre-service teachers to take up and enact teaching practices aligned with such asset-based orientations, challenges that are often amplified by gaps that exist between pre-service teacher education and school teaching contexts. The goal of this study is to examine pre-service teachers' orientations to the role of students' thinking in instruction as they planned and reflected on their own teaching across the contexts of their development. Around their work to plan and enact lessons in a final university teaching methods course context, and in their subsequent in-school mentored teaching context, I ask how a three pre-service science teachers oriented to the role of students thinking in instruction. Insights from this study include furthering an approach to understanding the two-worlds pitfall thought pre-service teachers' thinking about teaching practice, especially through making salient for pre-service teacher tensions that may be productive for their further development across contexts.

Strand 8: In-service Science Teacher Education

Toward a Framework for Equity-Focused STEM Teacher Leadership

Matthew Kloser*, University of Notre Dame, USA
Michael Szopiak, University of Notre Dame, USA
Catherine Wagner, University of Notre Dame, USA
D'Anna Pynes, University of Notre Dame, USA
Gina Svarovsky, University of Notre Dame, USA

ABSTRACT

Increased attention to STEM education highlights the need for leadership within and across schools to provide young people a high-quality STEM learning experience. For many reasons -- the retention of STEM teachers amidst a growing exodus from classrooms, a range of

understandings of what constitutes STEM education from different stakeholders, or creating greater capacity for curricular and instructional innovations -- the need for STEM teacher leaders who provide both excellent instruction and guidance for the broader school community is increasingly important. Therefore, the need exists for a coherent framework that draws on the research literature, is informed by what happens in schools and classrooms, and is centered on issues of equity for STEM education leaders who can speak to both the goals of each discipline and identify innovative integration and problem-solving across multiple disciplines. This conceptual paper seeks to expand our knowledge of STEM teacher leadership in three significant ways by: 1) framing three attributes central to a high-quality STEM learning environment; 2) introducing a multi-part framework that is drawn from multiple literatures to reflect the dispositions, knowledge, and practices for a STEM teacher leader, and 3) support the need for such a framework with initial evidence from aspiring STEM teacher leaders.

Strand 8: In-service Science Teacher Education

Incoherence in Administrators' Perceptions of Elementary Engineering Education and Teacher Professional Development Needs

Danielle Rhemer*, Florida State University, USA
Minjung Lee, Old Dominion University, USA
Kristie Gutierrez*, Old Dominion University, USA
Jennifer Kidd, Old Dominion University, USA

ABSTRACT

National and many state standards require elementary teachers to teach engineering in their classrooms. However, incorporating engineering into elementary engineering classrooms has not been a standard practice, thus emphasizing the need for teachers to be provided with training, resources, and support in order for the vision of instruction described in the standards to become a reality. School division and building-level administrators are responsible for making decisions regarding the training and support available to teachers. In response, we explored the perceptions of division and building-level administrators throughout Virginia regarding the current state of elementary engineering education and what they perceive as barriers to their teachers engaging students in lessons that incorporate engineering practices. Our data comes from 11 questions of a multiple-choice and open-ended response survey which was analyzed using a mixed method approach. Overall, findings describe a lack of connection between what administrators perceive as the current state of engineering education, the barriers to teachers engaging their students in engineering, and what supports are being provided to teachers. These findings have implications for professional development design and implementation.

Strand 8: In-service Science Teacher Education

Science Professional Learning that Offers Growth in Engineering Self-Efficacy for Rural School Elementary Teachers

John Galisky*, UC Santa Barbara, USA
Meghan Macias*, WestEd, USA
Ashley Iveland*, WestEd, USA

Martha Inouye, University of Wyoming, USA
Rebekah Hammack, Purdue University, USA
Julie Robinson, University of North Dakota, USA
Cathy Ringstaff, WestEd, USA
Ryan Summers, University of North Dakota, USA

ABSTRACT
Despite the intent to advance engineering education with NGSS, teachers across all grades lack self-efficacy in engineering pedagogy. Instructional shifts envisioned by NGSS, especially with inclusion of engineering, require substantial learning by teachers. For rural schools, due to geographic location and smaller collegial networks, there are challenges in providing content-specific professional learning. This project gathered researchers from four states to provide PL aligned to NGSS and delivered remotely to 150 rural teachers. In summer 2023, experts led a five-day workshop which modeled shifts called for by NGSS (e.g., equitable, discourse-rich, phenomena-based) and provided opportunities to experience next-generation teaching and learning. Likert scale surveys were collected before and after the workshop to gauge self-efficacy regarding teaching science and engineering. We found that science-focused PL, with engineering embedded rather than as stand-alone component, afforded growth in self-efficacy for teaching engineering. Pre-workshop surveys showed that teachers had higher self-efficacy towards teaching science than teaching engineering (Wilcoxon signed-rank; $p<.001$). Positive attitudes toward teaching science were leveraged to provide PL and pre-workshop to post-workshop analysis showed growth in self-efficacy towards teaching engineering ($p<.001$). Results are important for professional learning around teaching engineering, for professional learning with rural teachers, and for remote access to professional learning.

Strand 10: Curriculum and Assessment

Evaluation of NGSS Practices Curricular Integration: How Many, How Much, and How Often?

Amanda Peel*, New Mexico State University, USA
Steven McGee, The Learning Partnership, USA

ABSTRACT
A large urban midwestern district in the United States found that the schools in their wide-spanning district utilized curricular materials of varying rigor. The district began a Curriculum Equity Initiative (CEI) to ensure all schools in the district had equitable access to rigorous standards-based curricula. The CEI resulted in the development of a new high school curriculum, called Name (blinded for review), for Biology, Chemistry, and Physics available to all district teachers via an online platform. This curriculum was designed to align with the Next Generation Science Standards, which includes the Science and Engineering Practices that are mean to engage students in "doing science" to learn science (NGSS Lead States, 2013; NRC, 2012). This paper presents an evaluation of the new curriculum in terms of NGSS practices. The research question is: How are NGSS practices integrated into the district’s new curriculum? The most prevalent practice was Obtaining, Evaluating, and Communicating Information, followed by Constructing Explanations and Designing Solutions, Engaging in Argument from Evidence, and Modeling. Asking Questions, Investigations, Data Analysis, and

Math/CT were integrated the least. Comparisons between subjects and correlations are presented. This work begs the questions of NGSS practices: How many, How much, and How often?

Strand 10: Curriculum and Assessment

Promoting Model-informed Reasoning Through Engagement with Multiple Models

Jamie Elsner*, University of North Carolina at Chapel Hill, USA
Eric Kirk, University of North Carolina at Chapel Hill, USA
Zhen Xu, University of North Carolina at Chapel Hill, USA
Laura Zangori, University of Missouri, USA
Li Ke, University of Nevada Reno, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA

ABSTRACT

In this design-based research project, students engage with multiple models, including a systems model, mechanistic models, and a computational model to help them make sense of viral pandemics. Viral pandemics such as COVID-19 are socioscientific issues (SSIs) since they relate science concepts (e.g., infectious disease spread) to societal problems (e.g., availability of hospital beds). We contend that incorporating multiple modeling experiences into SSI-based instruction is beneficial for students because it helps them consider the usefulness and limitations of different types of models that when combined offer a more complete picture of the complex issue. Based on multiple design iterations, we develop conjectures for how multiple models can be sequenced to optimally support student learning of SSIs and enhance their understanding of modeling practices. In addition, we provide design principles to support the implementation and instruction of multiple modeling activities in science classrooms.

Strand 10: Curriculum and Assessment

Evaluating a Genetics Unit from a Science Identity Perspective

Sarah Fogelman*, Boston College, USA
Maria Moreno Vera*, Boston College, USA
Katherine McNeill*, Boston College, USA

ABSTRACT

Science identity refers to an individual's identification with the field of science and their sense of belonging, engagement, and affiliation with science-related activities, values, and communities (Kim et al., 2018; Carlone, 2022). A lack of representation and opportunities to engage in science, however, promote anti-science identities particularly among marginalized populations (Pinkard et al. 2017). Research shows the impact that curriculum materials can have on teacher and student learning, including attitudes and motivation towards science (Roblin et al., 2018). Nonetheless, little is known about which aspects of curriculum play a role in students' engagement with science practices. Given the potential that curriculum materials have in promoting equitable science instruction, this study set out to analyze the extent in which the genetics unit of a reform oriented storyline curriculum promotes positive student science identities with self-concept, perspective-taking, and community as evaluating criteria. Findings show that the curriculum promotes all three criterias but that there is room for expanding the depth in which science identity is fostered, particularly in the perspective-taking criteria.

Strand 10: Curriculum and Assessment

Assessing Middle School Chemistry Concepts Using Pictorial and Verbal Multiple-Choice Questionnaires

Einat Ben Eliyahu*, Ben Gurion University of the Negev, Israel
Eylon Langbeheim, Ben Gurion University of the Negev, Israel

ABSTRACT
Students' performance on concept tests may be significantly affected by the representational format of testing items, which is often taken for granted. Visual representations, in particular, can sometimes clarify concepts, but can also cause additional conceptual barriers for students who are unfamiliar with the information disclosed. Our study examines the reliability of assessment of basic chemistry ideas when they are presented visually or verbally. We found that the pictorial version was more difficult than the verbal one, due to items that contain representations such as graphs and scales. Also, we found significant differences in the students' performance in the verbal format compared to the pictorial format in certain items. Moreover, students' differences in representational competence, can explain much of the difference between their performance on pictorial version when compared to verbal version. This quantitative tool can be used to measure students' understanding of basic chemistry concepts and to estimate their confidence in those understandings, efficiently and quickly.

Strand 10: Curriculum and Assessment

Mediation among Epistemic Orientation and Epistemic Tools on Teacher Implementation of Knowledge Generation Approaches

Gavin Fulmer*, NWEA, USA
Amanda Duffey*, University of Iowa, USA
Brian Hand, University of Iowa, USA
Jee Kyung Suh, University of Alabama, USA

ABSTRACT
We study the role of teachers' understandings of epistemic tools as a mediator between their epistemic orientations and their observed classroom environment for knowledge generation. Epistemic orientations are teachers' views about the nature of knowledge, who plays a role in knowledge generation, and how. Epistemic orientation can affect how teachers view and plan for learning environments. We use a four-factor epistemic orientation approach: epistemic alignment, student ability, epistemic authority, and nature of knowledge. Epistemic tools are resources, materials, or heuristics that necessary for or that support knowledge generation and validation. Three essential epistemic tools in science learning are language, argument, and dialogic interactions. Data come from elementary science teachers to test the effects of epistemic orientation on practice can be fully mediated by their understanding of epistemic tools. Understanding of Argument is the largest significant

predictor of classroom implementation. Argument is also significantly predicted by views of epistemic alignment. While prior work emphasizes the fundamental role of language, the measure on language as an epistemic tool is not associated with differences in classroom environments. We conjecture that argument is more substantially related because teachers have greater variation in their views about it and understanding of it.

Strand 11: Cultural, Social, and Gender Issues

Designing for Low-High Spaces in White Science Teacher Education

Jonathan McCausland*, New Mexico Highlands University, USA

ABSTRACT

This proposal captures how low-high spaces might be leveraged in science teacher education to support white interns in learning about white supremacy in science teaching and society. Drawing from critical whiteness studies, specifically theorizing around low and high spaces (Lensmire, 2017) as well as white and nonwhite zones (Thandeka, 1999), this study draws upon storytelling to describe how white interns in a secondary science program participated in a designed low-high space. Ultimately, this proposal argues that low-high spaces creates opportunities for white people to begin to understand white supremacy in new ways and participate in a white community in ways that may support anti-racist efforts in science education.

Strand 11: Cultural, Social, and Gender Issues

Student Outcomes through Culturally and Linguistically Responsive Science Instruction: A Systematic Review

Niki Koukoulidis*, University of Florida, USA
Julie Brown*, University of Florida, USA

ABSTRACT

This systematic literature review was conducted to identify how culturally and linguistically responsive instruction (CLRI) is being studied in the field of K-12 science education and its implications for student outcomes, specifically for multilingual learners (MLs). Using the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) protocol, we screened, selected, and reviewed 20 studies published in the last two decades pertaining to how CLRI impacted MLs' engagement with and achievement in K-12 science education. Teacher practices were coded with a protocol for CLRI while student outcomes were further analyzed for the presence of cognitive and affective domains of learning. We found that many studies include student outcomes pertaining to both cognitive and affective domains, reinforcing the significance between acquisition and application of scientific knowledge and skills, and emotions, attitudes, and values that influence learning. While all CLRI elements were observed, there was an overrepresentation of attention to language and the use of multiple modalities and a scarcity of instruction that affirms students' science identities and engages them in sociopolitical consciousness. While we acknowledge limitations of conducting such a review, we illuminate potential spaces for future work to continue to better how science education is experienced by multilingual learners.

Strand 11: Cultural, Social, and Gender Issues

Teachers' Views and Response to Equity Issues at Higher Education Science Classroom in Bangladesh

S M Hafizur Rahman*, Institute of Education and Research (IER), University of Dhaka, Bangladesh
Sonia Yeasmin*, Institute of Education and Research (IER), University of Dhaka, Bangladesh

ABSTRACT

Ensuring equity in classroom practice, specially, in science classroom of higher education is undoubtedly important for developing competent, skilled and knowledgeable scientific individuals. It is also necessary to comprehend higher education science teachers' views about equity and equity issues that redirect their response to address those issues in classroom context. The purpose of the study was therefore to explore teacher's views about equity issues and their responses to provide with all the students appropriate science-related knowledge, skills and values. The study employs a mixed-methods approach, collecting data from science teachers, education experts, and students at higher education level. The findings reveal that teachers have gap in adequate understanding of equity issues. It highlights the need for designing training to enhance teachers' grasp of equity concepts and inclusive pedagogical practices. Moreover, the research emphasizes the necessity of providing students with varied, accessible science-related knowledge, skills, and values through diverse teaching methods. It reveals shortcomings in addressing equity issues within classrooms, indicating a need for comprehensive reforms in science education. This study contributes to a deeper understanding of equity in higher education science classrooms, offering insights for educators, policymakers, and stakeholders to create more equitable and inclusive learning environments.

Strand 11: Cultural, Social, and Gender Issues

Queerness in STEM: A Review of National Science Foundation (NSF) Research Grants

George Schafer*, Drexel University, USA

ABSTRACT

Queer people in America are underrepresented in multiple ways including acquisition of jobs, persistence in higher education, and research that is focused on queer identity, with such underrepresentation especially prominent in STEM fields. This study seeks to understand how the National Science Foundation (NSF) has historically supported queer people through the award of research funding (grants). A systematic review of research grants was conducted, using a 3-tier set of criteria. Through document analysis, this study found that (especially before the 2015) there are very few funded queer-focused research grants. Drawing from these results and extant literature on the intersections of queerness and STEM, the author argues for a significant increase in NSF's support of LGBTQ2IA+ individuals in America.

Strand 11: Cultural, Social, and Gender Issues

Centering Biodiversity: Queering Sex Determination in a Developmental Biology Course

Aramati Casper*, Colorado State University, USA

Brandon Hylton, Colorado State University, USA
Deborah Garrity, Colorado State University, USA

ABSTRACT
In biology variation is the norm not the exception; this holds true for the concepts of sex and sex determination. Unfortunately, these topics are often taught from an oversimplified perspective, that sex is a simple, genetically determined binary. We used master narrative theory to explore the question, how did students' conceptions of sex and sex determination change between the pre- and post-tests, in a developmental biology course. Twenty-five of the 48 students participated in our study. We used reflexive thematic analysis to develop three themes: 1) sex is at least a little bit complex in humans; 2) definitions of sex changed in many, sometimes undesired, ways; and 3) theoretical topics changed to desired conceptions more easily. These themes reflect the ways students' conceptions changed and engage with how the topics taught in the course may have influenced how students' conceptions changed. These results demonstrate that seemingly simple topics that are societally entrenched, such as defining the concept of sex, may be more difficult to shift than more complex theoretical concepts that are less entrenched.

Strand 12: Technology for Teaching, Learning, and Research

Science Practices Innovation Notebook: A Framework for Inclusion

Erin Peters-Burton*, George Mason University, USA
Timothy Cleary, Rutgers University, USA
Peter Rich, Brigham Young University, USA
Anastasia Kitsantas, George Mason University, USA
Brittany Miller, George Mason University, USA
Hong Tran, Purdue University, USA
Haley Mckeen, George Mason University, USA

ABSTRACT
Authentic science experiences, those that mimic the practices of science professionals in a real-world context, have been effective in helping all students gain insights into the disciplinary processes and principles in STEM learning. The purpose of this proposal is to explain the design of the Science Practices Innovation Notebook (SPIN), which is an online learning environment that supports high school science learning about data practices in an authentic context using self-regulated learning (SRL). SPIN was developed as part of a collaborative partnership between four researchers and 20 high school science teachers. Our researcher-practitioner partnership focused on developing SPIN, a web-based science notebook, that (a) focuses science investigations on data practices, (b) supports computational thinking (CT) by providing computational tools to process data, (c) enables students to maintain a complete record of their work on activities and tasks, (d) supports students' SRL through a series of customizable prompts, (e) promotes social collaboration and co-regulation among students, and (f) gathers analytics on student SRL behaviors and thought processes for teacher instructional use. The features of SPIN that are used to support all students are explained and preliminary data on teacher observation of student supports are reported.

Strand 12: Technology for Teaching, Learning, and Research

Student Attributions for Success and Failure in General Chemistry Found in an Online Metacognitive Intervention

Ted Clark*, The Ohio State University, USA

ABSTRACT

Interventions to improve student metacognitive awareness and encourage use of evidence-based learning strategies have become increasingly popular in introductory STEM courses. In this investigation a popular in-class intervention based on McGuire's book "Teach Students How to Learn" has been transformed into an interactive asynchronous video delivered using the program Perusall. The goal of this investigation is to evaluate, and add to, McGuire's claims concerning the inclusion of performance data to persuade students to adopt a growth mindset and implement new strategies. This has been accomplished by analyzing student perspectives on, and attributions for, student success on a chemistry exam when performance data for the exam and for a chemistry pre-test are provided. Results indicate that student attributions strongly favor internal factors consistent with a growth mindset to begin the course. Motivation and behavior are identified as the leading contributors to student success, with the use of more effective learning strategies being a secondary factor. Aspects of student metacognition, over-confidence, and how a reliance on prior knowledge can lead to diminished engagement are points raised by students at the beginning of the intervention to explain under-performance on exams by their peers.

Strand 12: Technology for Teaching, Learning, and Research

Investigating New Roles for Digital Technology in Teaching Computer Studies in Africa Through a Virtual-Learning-Environment

Deborah Agbanimu*, National Open University of Nigeria, Nigeria
Peter Okebukola, Lagos State University-ACEITSE, Nigeria
Juma Shabani, Univeristy of Burundi, Burundi
Franklin Onowugbeda, Lagos State University-ACEITSE, Nigeria
Esther Peter, Lagos State University-ACEITSE, Nigeria
Adekunle Oladejo, Lagos State University-ACEITSE, Nigeria
Olasunkanmi Gbeleyi, Lagos State University-ACEITSE, Nigeria
Ibukunolu Ademola, Lagos State University-ACEITSE, Nigeria

ABSTRACT

This study investigated the effectiveness of the Agbanimu 1.0 model, a virtual learning environment developed using MOODLE to promote meaningful learning of computer studies in junior secondary schools, by releasing students from the constraints of fixed and rigid schedules and physical limitations and releasing them into an information world that responds to learners' being able to study at their own pace. The design was sequential explanatory (mixed methods). The study had 196 junior secondary school students from two purposively selected schools in Lagos State Education District V. flowchart and algorithm achievement test (FAAT) with a reliability coefficient of 0.74 was used to gather the quantitative data. Following the pretest, the experimental group underwent four weeks of

instruction utilizing the Agbanimu 1.0 model, while the control group underwent the conventional teaching method, followed by the posttest. The ANCOVA output results revealed a statistically significant difference in the achievement measure (F = 1,195 = 27.30 p.05), favoring the experimental group (12.11; control = 10.07). Within the study limits, it was concluded that a virtual learning environment like Agbanimu 1.0 can enhance students' academic performance and also encourage lifelong learning.

Strand 12: Technology for Teaching, Learning, and Research

Exploring Promises and Pitfalls of Artificial Intelligence in Education: A Pilot Study

Divya Baranwal*, Southern Methodist University, USA

ABSTRACT

The increasing popularity of artificial intelligence (AI) among university students is undeniable. Previous Studies focused on supporting education/instruction by artificial intelligence systems and scrutinizing them based on different educational approaches. This study aimed to explore the promises and pitfalls of Artificial Intelligence (AI) in education. The participants were fifty-five international students studying at a national university in Taiwan. The investigator developed the questionnaire and validated it with two experts. The collected data were analyzed using the content analysis method and classified under themes. Analysis showed that participants understand AI, desire an AI-driven life for its convenience and improvement, and foresee AI enhancing education as a remedy for better student learning. The potential advantages of incorporating AI into the teaching-learning process can support students' learning and teachers. Despite that, they nicely informed about the deterrents of AI in education.

Strand 12: Technology for Teaching, Learning, and Research

Exploring Automated Evaluation of Teacher Attention to Student Ideas During Argumentation-Focused Science Discussions

Jamie Mikeska*, ETS, USA
Alessia Marigo, ETS, USA
Jessica Tierney, ETS, USA
Tricia Maxwell, ETS, USA
Duy Pham, ETS, USA
Beata Beigman Klebanov, ETS, USA

ABSTRACT

The study examined how elementary preservice teachers (n=5), in-service teachers (n=6), and teacher educators (n=4) perceive, understand, and evaluate formative feedback that was generated by the automated evaluation of one instructional feature of facilitating argumentation-focused discussions -- attending to student ideas equitably and responsively. We used the results from a prior study that involved automated evaluation of dialogue between students and teachers in simulated teaching experiences (Author et al., 2023b) to create an automated feedback report illustrating teachers' strengths and areas of growth for seven feedback components related to their ability to attend to student ideas equitably and responsively when facilitating a science discussion. Data collected involved each of the

fifteen participants reviewing a feedback report about a science discussion that they or a teacher facilitated in an online simulation classroom and then completing an online survey and semi-structured interview to share their perceptions of, understanding about, and evaluation of the feedback report. Findings showed that participants had primarily positive perceptions of and exhibited a high level of understanding across feedback components, which suggests that these types of automated feedback reports have potential to support teacher learning, especially when used in tandem with digital approximations.

Strand 12: Technology for Teaching, Learning, and Research

Cultivating Hardware Engineering Interest in High School Students Using Hands-on Learning

Andrea Ramirez-Salgado*, University of Florida, USA
Pavlo Antonenko, University of Florida, USA

ABSTRACT

Semiconductors and microchips are vital in modern society as they form the foundational components for electronic devices and technological progress. The computer hardware industry faces a global chip shortage, emphasizing the demand for skilled engineers in electronic component manufacturing. Supporting high school students' interest in hardware computing becomes essential, potentially increasing their chances of pursuing careers in this field.
Our study aims to cultivate high-school students' situational and individual interest in computer hardware. We designed a hands-on curriculum involving diverse and inclusive learning experiences, focusing on the scientific aspects of hardware principles. This curriculum includes simulations, hands-on circuit design, applications involving Field-Programmable Gate Arrays (FPGAs), and collaborative projects to address real-world challenges through FPGA-based solutions.
We conducted a six-week summer seminar involving six high school students from different schools across the US. We collected data through surveys measuring students' individual interest before and after the seminar and semi-structured focus groups to assess their situational interest. Our findings indicated that the seminar facilitated a transition from initially triggered situational interest to a more sustained form. Results also suggested a positive impact on students' interest in computer hardware engineering careers.

Strand 12: Technology for Teaching, Learning, and Research

Technology to Support the NGSS Practice of Mathematical and Computational Thinking in Early Elementary Classrooms

Kristina Tank*, Iowa State University, USA
Tamara Moore, Purdue University, USA
Anne Ottenbreit-Leftwich, Indiana University, USA
Barbara Fagundes, Purdue University, USA
Zarina Wafula, Iowa State University, USA
Sohheon Yang, Indiana University, USA

ABSTRACT
As elementary teachers are implementing CT into their classrooms, many are using various forms of educational technologies to help them in this endeavor. However, as we seek to better understand how to promote CT thinking with early elementary students, there must also be a focus on better understanding how computational thinking tools support learners. CT tools and technology are an important part of the medium through which children learn to think computationally and warrants attention as each technology may uniquely influence how, or what, students learn. The purpose of this work is to share examples of how technology has been integrated alongside CT instruction in early elementary classrooms. This study uses a multiple case study design to examine the following research questions: What are appropriate technology tools for CT instruction in early elementary classrooms? How do these tools support early elementary students to think computationally? There are three cases of implementation that span the grade levels K-2 for different technology tools: Robot Mouse, Tale-Bot, and ScratchJr. For this presentation, the case descriptions from each of the cases will be presented in more detail along with findings related to what we learned from our within and cross-case analysis.

Strand 13: History, Philosophy, Sociology, and Nature of Science

Exploring the Development of Students' Nature of Engineering Views and their Identification with Engineering

Jacob Pleasants*, University of Oklahoma, USA

ABSTRACT
In the United States and around the world, attention is being increasingly paid to engineering as part of science and STEM education, often in support of the project of preparing the "STEM Workforce." In view of that goal, an objective of engineering education is to stimulate student interest in and identification with engineering. This, in turn, requires developing students' understanding of what engineering is and what engineers do – what is often referred to as the Nature of Engineering (NOE). This study reports early research findings from an ongoing longitudinal project that follows students who participated in an Engineering Summer Bridge (ESB) program. The ESB program provides incoming freshman engineering students with a set of learning experiences that focus on building students' engineering knowledge and skills, including their understanding of the NOE. This study examines changes in students' NOE knowledge and engineering motivations and interests before and after the ESB experience. It explores how students' NOE views develop in tandem with their identification with engineering, and how those processes potentially interact with each other.

Strand 13: History, Philosophy, Sociology, and Nature of Science

Towards a Multidisciplinary Framework for Teaching Socio-scientific Issues

Scott Bonham*, Western Kentucky University, USA

ABSTRACT
Addressing socio-scientific issues (SSIs) is crucial for science instruction and must not ignore the socio-cultural aspects. Towards that goal this work develops a model of SSIs as clashing

socio-scientific paradigms and a multi-disciplinary framework with guiding questions to better understand those paradigms. This is then illustrated with an example of using it to analyze the clashing paradigms in biological evolution and guide instructional choices.

Strand 13: History, Philosophy, Sociology, and Nature of Science

Re-evaluating the Impact of School Size on Students' Physical Science Enrollment and Performance

Monika Siepsiak*, Stony Brook University, USA
Keith Sheppard, Stony Brook University, USA
Angela Kelly, Stony Brook University, USA

ABSTRACT

New York City public schools have undergone a substantial shift in organization throughout the past two decades. The national small schools' movement, implemented due to poor academic performance and high rates of misconduct, resulted in many historically large city schools being split from one unified institution to multiple independent schools located in the same building. This drastic change had a multitude of different implications on the education of public-school students. This quantitative study examined some of the longitudinal implications of the small school movement, specifically the change in school size, on students' academic enrollment and performance in the physical sciences, Physics and Chemistry, from 1997 to 2022. This research utilized publicly available archived data from the New York State School Report Cards database available on the New York State Education Department (NYSED) website. The context scope includes three high schools throughout different boroughs of New York City which were subsequently divided into smaller educational facilities. The high school campuses being analyzed include Martin Luther King Jr. Educational Complex in Manhattan, Adlai E. Stevenson Educational Complex in the Bronx, and Thomas Jefferson High School in Brooklyn.

Strand 14: Environmental Education and Sustainability

Mothers as Ambassadors of Climate Change Behaviors Education: Multi-Case Study between Mexico and United States

Regina Ayala Chavez*, NC State University, USA
K.C. Busch, NC State University, USA

ABSTRACT

Several studies have shown that households contribute more than 60% of global greenhouse gas emissions (Long et al., 2022; Miehe et al., 2015). However, this source has significant opportunities to reduce emissions, changing residents' behaviors (Stankiewicz et al., 2019; Naimir et al., 2019). This research is focused only on mothers because they are more willing to engage in climate change behaviors than men (Hunter et al., 2004; McCright, 2010) and can influence their children's behaviors (Hahn, 2021; Habib et al., 2021).

This study interviewed twelve mothers from each country (Mexico and the U.S.A.) to understand the main factors that motivate them to engage in climate change behavior, how they influence their children, and how they learn about climate change.

The main reason to engage in these behaviors is caring about the environment, people, and their children's future. It also showed that mothers educate themselves about climate change and then expand this knowledge through their community. It was found that they influence not only their kids and partners, but also their neighbors, friends, school boards, and local government. This research shows what can be a snowball effect of teaching and learning about climate change in an informal setting led by mothers.

Strand 14: Environmental Education and Sustainability

Understanding Teachers' Knowledge and Confidence in Teaching Climate Change & Marine Science

Lauren Madden*, The College of New Jersey, USA
Louise Ammentorp, The College of New Jersey, USA
Nathan Magee, The College of New Jersey, USA
Graceanne Taylor, Save Barnegat Bay, USA

ABSTRACT

This presentation provides a tangible example of a professional development initiative that built a caring, collaborative community while preparing teachers to implement climate change and marine science instruction. We report our findings on growth in teachers' understanding of, and confidence in, teaching marine science and climate change in NGSS-aligned lessons after a series of three workshops. As part of an ongoing professional development project, we worked with three cohorts of preservice and practicing teachers (N = 30), who each participated in a three-workshop program. We conducted a focus group discussion with a subset of nine participants to better understand the effectiveness of this professional learning series in facilitating changes in teachers' knowledge and confidence in teaching about climate change and marine science in NGSS-aligned lessons. We found that teachers' understanding of and confidence in teaching in all three areas (marine science, climate change, and the NGSS) increased as a result of the PD. Additional themes emerged including the value of collaborating with peers at the workshops, using tools and strategies in the workshops to enhance their teaching, and the importance of place-based learning also emerged.

National Center for Science Education
Sponsored Session
Safeguarding Sound Science – Resolving Science Misconceptions in the Secondary Classroom

18-Mar-24, 5:30 PM-6:15 PM
Location: Governor's Square 10

Safeguarding Sound Science – Resolving Science Misconceptions in the Secondary Classroom

ORGANIZERS

Amanda Townley, National Center for Science Education, USA

Lin Andrews, National Center for Science Education, USA
Wendy Johnson, National Center for Science Education, USA

ABSTRACT
The National Center for Science Education has advocated for the scientific community for over forty years. While widely known for catalyzing action by tracking local policies and state legislation that undermines the integrity of science education as one of our primary objectives, in the last five years, we have broadened our outreach into science education research as well as supporting teachers across the country. This session will detail NCSE's areas of outreach, our current projects, and ways we are available to partner with various organizations.

PhET Interactive Simulation, CU-Boulder
Sponsored Session
Discover PhET-iO Simulations for Research with Full API Control and Backend Data
18-Mar-24, 5:30 PM-6:15 PM
Location: Governor's Square 11

Discover PhET-iO Simulations for Research with Full API Control and Backend Data

ORGANIZERS
Kathy Perkins, University of Colorado Boulder, USA

PANELISTS
Kathy Perkins, University of Colorado, Boulder, USA
Amy Rouinfar, University of Colorado, Boulder, USA
Kathryn Woessner, University of Colorado, Boulder, USA

ABSTRACT
In this workshop, the PhET Interactive Simulations team from University of Colorado Boulder will introduce PhET-iO simulations (sims), which are versions of PhET sims enhanced with new capabilities that can empower education researchers and open up new research directions. With the PhET-iO version of a sim, researchers can now: 1) easily customize the starting state of the sim (e.g. hiding and showing any of the controls and preconfiguring a set up), 2) leverage an API to fully integrate the sim into an instructional wrapper (e.g. monitor for a state, collect experimental data into a table, or change the sim configuration mid-activity), and 3) capture backend data on student interactions or simulation states for learning analytics analysis. We will share some examples of research done with PhET-iO sims, invite participants to explore some PhET-iO sims and their current capabilities, co-design a mini-assessment task, and discuss the future of PhET-iO sims for research.

International Journal of Science Education
Social Event
IJSE Reception
18-Mar-24, 6:30 PM-7:30 PM
Location: Plaza Ballroom ABC/DEF

Research in Artificial Intelligence-Involved Science Education (RAISE)
Sponsored Session
RAISE Book Talk: Uses of Artificial Intelligence for STEM Education
18-Mar-24, 7:00 PM-9:00 PM
Location: Directors Row I

RAISE Book Talk: Uses of Artificial Intelligence for STEM Education

ORGANIZERS
Xiaoming Zhai, University of Georgia, USA
Kent Crippen, University of Florida, USA

PANELISTS
Joe Krajcik, Michigan State University, USA

ABSTRACT
The RAISE Book Talk, chaired by Kent Crippen, will delve into the "Uses of Artificial Intelligence in STEM Education", edited by Xiaoming Zhai and Joe Krajcik. This insightful session aims to foster discussions about AI's challenges and opportunities in STEM education. The book, comprising 26 chapters, explores the balance between human tasks and AI tools, showcasing AI's transformative potential in automated scoring, intelligent tutoring, and adaptive learning across STEM subjects. It also addresses supporting diverse learners, including those with disabilities, and ethical considerations in AI education. The session begins with an introduction and insights from the editors, followed by authors sharing overviews of their chapters, reflecting on AI integration's strengths and weaknesses in STEM classrooms. An open discussion allows participants to share experiences and ideas, concluding with the chair summarizing key takeaways and potential future research avenues. Designed for educators and researchers, participants will gain understanding of AI applications, insights into AI's practical classroom implications, and opportunities for networking and collaboration.

Equity And Ethics Committee
Social Event
Equity & Ethics Committee Dinner
18-Mar-24, 7:00 PM-9:00 PM
Location: Off Site

Equity & Ethics Committee Dinner

ORGANIZERS
Phillip Boda, University of Illinois, USA
Iliana De La Cruz, Texas A&M University, College Station, TX, USA

ABSTRACT
Come one, come all! NARST's Equity & Ethics Committee is hosting their annual dinner event at Denver Downtown's YardHouse Monday night, March 18, 2024, starting at 7 pm (address: 1555 Court Place). Located right around the corner from the conference venue, our reception-style dinner will offer a host of appetizing foods. Please purchase your tickets in advance during conference registration, or select an option to donate for others to attend!

19 MARCH 2024

Committee Meeting
Publications Advisory Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 10

Committee Meeting
Social Media, Website, Communications Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 11

Committee Meeting
Program Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 12

Committee Meeting
Elections Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 16

Committee Meeting
Awards Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 17

Committee Meeting
Research Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 1

Committee Meeting
Equity and Ethics Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 2

Committee Meeting
External Policy and Relations Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 3

Committee Meeting
International Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 4

Committee Meeting
Graduate Student Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 5

Committee Meeting
Membership Committee Meeting
19-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 6

Roundtables Session 2
19-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Ballroom ABC/DEF

Strand 6: Science Learning in Informal Contexts
Roundtable

STEMming the Slide: Enhancing Self-Efficacy via a Summer Academy

Caleb Smith*, Southeastern Oklahoma State University, USA
Katheryn Shannon*, Southeastern Oklahoma State University, USA
Michael Hardy*, Southeastern Oklahoma State University, USA

ABSTRACT

A STEM Summer Academy offered rising 8th and 9th grade students an interactive STEM learning experience over the course of 5 days during a commuter summer academy. Students kept journals and blogs during the experience and completed post-academy surveys and participated in semi-structured interviews at the close of the academy. Data collected from students are used to evaluate the Academy experience in 1) deepening participants' understanding of and ability to apply STEM content, 2) enhancing motivation to learn about and increase appreciation of STEM fields, and 3) increasing participants' self-efficacy as STEM problem solvers and practitioners.

Strand 6: Science Learning in Informal Contexts
Work-in-progress Roundtable

"Escaping the Room, Entering the Nano-World"- Learning about Nano through a Chemical Escape Room

Shelley Rap*, Weizmann Institute of Science, Israel
Malka Yayon, Weizmann Institute of Science, Israel
Ron Blonder, Weizmann Institute of Science, Israel

ABSTRACT

This study aims to investigate the educational potential of Chemical Escape Rooms (ChEsRms), focusing on a specific nanotechnology-themed escape room. Escape Rooms (EsRms) have gained considerable popularity as engaging recreational activities; they involve participants solving puzzles and deciphering codes within a confined timeframe to escape a designated room. Educational Escape Rooms (EdEsRms) have emerged as important tools that enhance learning by combining active learning approaches with game-based learning theories. This study introduces a ChEsRm that focuses on nanotechnology; it integrates physical and virtual puzzle-solving with a chatbot interface. This research seeks to address questions regarding how the ChEsRm affects students' knowledge, science proficiency, and their perception of nanotechnology's relevance, as well as teachers' perceptions of ChEsRm's efficacy. The methodology involves mixed methods including questionnaires and focus groups; it targets both students and chemistry teachers. Preliminary findings suggest that students associate everyday phenomena more with nanotechnology after engaging in the ChEsRm and show an improved understanding of nanomaterial properties. Teachers'

feedback indicates varying perceptions of the ChEsRm's effectiveness. This research contributes insights into the potential of ChEsRms for innovative subject learning, the importance of applying science in students' daily life, and the alignment between teachers' and students' perceptions.

The study was supported by the Science Career Awareness (SciCar) EU Twinning project. We are grateful to the Energy Research Initiative (SAERI) at the Weizmann Institute of Science for the long collaboration and support of the educational escape room project.

Strand 6: Science Learning in Informal Contexts
Roundtable

Kitchen Chemistry Boosts STEM Identity and Increases STEM Career Interests.

Chen Chen*, University of Hong Kong, Hong Kong
Jiaxin Chen*, University of Hong Kong, Hong Kong
Liang Ju, University of Hong Kong, Hong Kong
Gerhard Sonnert, Harvard-Smithsonian Center for Astrophysics, USA
Philip Sadler, Harvard-Smithsonian Center for Astrophysics, USA

ABSTRACT

Kitchen chemistry invites people to learn STEM by cooking food. It has become a popular pedagogy in pre-college science education to make STEM interesting and relevant to real life. Yet, we don't know how much high school kitchen chemistry experience boosts college STEM identity and career interest. Using a large U.S. national sample of freshman college students (N = 15,725), we explored how kitchen chemistry experiences during the high school years were associated with the students' STEM identity and their STEM career interests. For STEM identity, we found a gender interaction. Participation in kitchen chemistry activities had a stronger positive effect on STEM identity for girls than for boys, thus narrowing the gender gap. STEM-related career interests (including medicine and health) were boosted widely by kitchen chemistry experiences, with those effects applying equally to all students, regardless of their gender and race/ethnicity.

Strand 6: Science Learning in Informal Contexts
Work-in-progress Roundtable

Storied Experiences of Informal Science Learning in U.S. College Students and Impacts on Science Identity

Paul Le*, University of Colorado Denver, USA
Sarah Hug, Colorado Evaluation and Research Consulting, USA

ABSTRACT

Informal science learning experiences are influential in students' science identity development because participation in non-classroom activities have an opportunity to strengthen or diminish a students' perception of what science is and if they have a place within scientific spaces to meaningfully engage. Students at a western U.S. community college completed two reflections in which they shared stories about their experiences in science, including informal science learning opportunities in their childhood that they found significant. Thematic and constant comparative coding resulted in three major themes that were found in students' reflections: (1) informal science learning helped students meaningfully develop interest, (2) relationships with others helped strengthen affinity towards science, and (3) students gained personal value in these experiences that shaped the ways in which they thought of science, which could promote impactful science identity development. Future directions will elucidate information on additional dimensions of science identity production and highlight how the ecology and ecosystem also influence students' science identity.

Strand 6: Science Learning in Informal Contexts
Work-in-progress Roundtable

Using Community Ethnography and Networks of Support to Foster Consequential Learning through Community-Centered Energy Engineering

Carlos Meza-Torres*, Arizona State University, USA
Michelle Jordan, Arizona State University, USA
Steve Zuiker, Arizona State University, USA

ABSTRACT

New models of science and engineering education are needed to transform learning from a siloed classroom activity to a community-based endeavor in which adults join together in networks of support to foster youths' community leadership in local energy transitions. Arguing that transformative opportunities for learning can be achieved by positioning youth as learners and contributors who confront the energy challenges facing their communities, we designed and enacted an afterschool community-centered energy engineering program that engaged middle and high school students in interactions with community members to design, prototype, and present three designs for a neighborhood park redesign project. Interaction analysis was guided by our intention to test our conjecture that productive STEM engagement can foster consequential learning by positioning students as learners and contributors through community-based energy engineering processes that facilitate interaction for and with community members. Preliminary findings support the conjecture and suggest implications for future instantiations of similar programming.

Strand 6: Science Learning in Informal Contexts
Work-in-progress Roundtable

Drawing from Narrative Techniques to Explore Impact Identity and Scientist Public Engagement: A Pilot Study

Brenda Guerrero*, Florida International University, USA

ABSTRACT

The value of university scientists' engagement with public audiences in terms of supporting increased scientific literacy and dispelling mistrust is well recognized across academic circles (Calice et al., 2022, Simis et al., 2016), yet research still lacks a comprehensive understanding of the factors that influence if and how university scientists engage these audiences (Jensen et al., 2008; AbiGhannam & Dudo, 2022). The novel concept of Impact Identity (Risien & Storksdieck, 2018) suggests that a scientist's multifaceted identities and diverse contexts influence participation in efforts to engage the public with scientific research. Risien and

Storksdieck (2018) identify these factors as the Dimensions of Impact Identity (DII), which they conceptualize include scientists' personal preferences, capacities and skill sets, scientific discipline, research and scholarship, institutional contexts, and societal needs. By considering the DII across diverse real-world contexts, researchers can gain a more holistic understanding of the multifaceted forces at play on individual scientist's patterns and behaviors in public engagement. This proposal describes the methods and outcomes of a pilot study with newly-developed interview protocols based on the concept of Impact Identity and related research in public engagement to better understand why and how university scientists engage the public with science.

Strand 7: Pre-service Science Teacher Education
Roundtable

BIPOC Teacher Candidates' Translanguaging Selves: Their Assets and Identities as Future Elementary Science Teachers

Patricia Venegas-Weber*, University of Washington, USA
Jessica Thompson*, University of Washington, USA

ABSTRACT

Understanding how the context of a Racially and Linguistically-Just Teacher Education Program (TEP) supports the translanguaging stance and Identity(ies) take up of Dual Language Bilingual Education (DLBE) Teacher Candidates (TCs) in their professional lives is important. Drawing on contextual artifacts, classroom observations, and Professional Learning Community (PLC) meetings data for three Black, Indigenous and People of Color (BIPOC) DLBE TCs, this qualitative comparative case study sheds light on the translanguaging stance development and intersecting identities that emerge for these BIPOC TCs as professional elementary science teachers. Using a Critical Consciousness lens, together with translanguaging theory and raciolinguicized subjectivity that underscore the relation between language and race, findings show how the context of these DLBE TCs supported them in developing their translanguaging stance as a critical part of their professional identity as justice oriented science teachers. We argue this stance goes beyond a practice, but a way of being, noticing, and building a new classroom culture with students. This study makes a contribution to understanding ways BIPOC prior knowledge and identities can be leveraged in TEP to support TCs translanguaging selves, a pluriverse context for science teaching identities to flourish and their pedagogical preparation.

Strand 7: Pre-service Science Teacher Education
Roundtable

Field Experience Reconceptualized for Elementary Science and Mathematics Methods Courses

Sheryl McGlamery*, University of Nebraska at Omaha, USA
Saundra Shillingstad*, University of Nebraska at Omaha, USA

ABSTRACT

The pandemic has had a significant impact on teacher preparation programs. With field experiences being one of the most effective pathways to connect theory to practice and a contributing source of preservice teachers' self-efficacy development, teacher preparation programs have had to reimagine these experiences. In this study, we share how our teacher preparation program incorporated microteaches to continue fostering self-efficacy during pandemic times and the potential implications of these programmatic adaptations. This qualitative study describes the efforts of one teacher preparation program striving to provide a reconceptualized field experience for their science and mathematics methods courses. Data was collected over a two-year period and the use of microteaching sessions were instituted and evaluated to see if the microteaching sessions could improve the self-efficacy of preservice elementary science and mathematics methods students. The microteaching sessions were in conjunction with traditional elementary classroom-based field experiences. The findings show that additional microteaching experiences do offer preservice elementary teachers more opportunity to plan and implement science and math pedagogies, in a setting where the pre-service teachers receive feedback from peers and instructors, does improve teaching efficacy in science and math teaching.

Strand 7: Pre-service Science Teacher Education
Roundtable

Using the Draw-A-Scientist Test to Understand Pre-Service Elementary Teachers' Perceptions of Scientists

Sissy Wong*, University of Houston, USA
Maria Walsh, University of Houston, USA
Samuel Katende, University of Houston, USA

ABSTRACT

Identifying and explicitly addressing pre-service teachers' perceptions of scientists is important because these views of scientists influence their students' perceptions of scientists. In fact, narrow perceptions of scientists can negatively impact teaching practices and choices. This study used two iterations of the Draw-A-Scientist to help pre-service elementary teachers identify their initial conceptions of scientists and how these perceptions changed after engaging in two semesters of equity-focused science methods courses. Findings show that the pre-service elementary teachers' perceptions changed towards more inclusive and diverse views of scientists after engaging in the two science methods courses.

Strand 7: Pre-service Science Teacher Education
Roundtable

Elementary Preservice Teachers' Competence in Planning and Implementing Empathic Design in Cross-Cultural STEM Education

Soo Won Shim*, Illinois State University, USA
Selcen Gauzy, Purdue University, USA

ABSTRACT

To provide authentic and holistic engineering education for K-12 students, it is critical for teachers to understand a human-centered design approach. Principles of human-centered design align with key features of cross-cultural education (Gleason & Jaramillo Cherrez, 2021). Just as empathy is a key quality for human-centered designers, empathy is also a critical

attribute for multicultural teachers (Warren, 2014). To enhance preservice teachers' pedagogical strategies regarding empathic techniques and culturally and socially responsive pedagogies, we proposed an empathic integrated STEM module. After experiencing the module, preservice teachers understood the role of empathy in both engineering and cross-cultural education. The module enhanced preservice teachers' pedagogical strategies in empathic integrated STEM instruction. Teachers discovered the benefits of the instruction and reported that they felt confident in integrating the instruction into their lesson plans. The study findings show that empathic integrated STEM instruction was an effective way to support preservice teachers' understanding of engineering pedagogical strategies, culturally responsive pedagogy, and the features of integrated STEM instruction.

Strand 7: Pre-service Science Teacher Education
Work-in-progress Roundtable

Supporting preservice science teachers to teach ambitiously: A collaborative self-study

Barbara Billington*, University of Minnesota - Twin Cities, USA
Eva Nelson*, University of Minnesota - Twin Cities, USA

ABSTRACT

Pre-service science teachers (PSTs) struggle to apply reform-based, student-centered, equity-minded theories to their beginning teaching practice. Many PSTs fall along a continuum of awareness of what needs to be done, a commitment to doing the hard labor of student-centered teaching, and enacting reform-based theories and practices. In this work-in-progress collaborative self-study, two teacher educators will meet weekly to reflect on their teacher moves and reform-based practices. Their reflections will be rooted in the practices and elements present in ambitious science teaching (Windschitl et al., 2018) to elucidate what strategies work to move PSTs beyond awareness to consistently and confidently enact reform-based pedagogies to meet the needs of all of their students. We anticipate that this collaborative self-study will be analyzed utilizing narrative inquiry. We look forward to sharing our progress on our collaborative self-study's implementation and request feedback from the workshop participants for guidance and recommendations for dissemination.

Strand 7: Pre-service Science Teacher Education
Work-in-progress Roundtable

Exploring How Elementary Preservice Teachers Develop Reform-Minded Science Teacher Identities Across a Science Methods Course

Jenna Gist*, Purdue University, USA
Brenda Capobianco, Purdue University, USA

ABSTRACT

This work-in-progress roundtable presentation explores how elementary preservice teachers create and recreate reform-minded science teacher identities in light of the Next Generation Science Standards across a one-semester elementary science methods course. The aim of this study will be to: 1) explore the different ways elementary preservice teachers construct and reconstruct their reform-minded science teacher identities during a science methods course; and 2) understand how changing contexts influence their identity development

during the methods course. To frame this study, researchers will use McAlpine and Amundsen's identity-trajectory theory. This study will take place during the Fall 2023 semester and utilize a qualitative comparative case study methodology. Data will be gathered via journey maps and autobiographical narratives; pre- and post- semi-structured interviews; observation field notes; and other course artifacts (e.g., final e-portfolios). Data will be analyzed using document analysis and open coding. Findings will be anticipated to inform the re-calibration of elementary science teacher preparation to better account for the inclusion of phenomena-based instruction; engineering design; three-dimensional learning; and ambitious science teaching.

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

Developing a Social Network Tool to Support and Characterize STEM Teacher Leadership

John O'Meara*, Montclair State University, USA
Shanna Anderson, Montclair State University, USA
Timothy Aberle, Montclair State University, USA
Ursula Derios, Montclair State University, USA
Mika Munakata, Montclair State University, USA
Monica Taylor, Montclair State University, USA
Emily Klein, Montclair State University, USA

ABSTRACT

Teacher Leaders (TLs) are integral to a school's instructional leadership. TLs "lead informally from the classroom" (Authors, 2019, p. 685) to "influence curricular and pedagogical change" (Authors, 2018 p. 93). They rely on their social networks to identify opportunities for leadership (Wergin, 2007). In this methodological paper, we aim to illuminate the nuanced work of science TLs through the use of a self-created social network mapping tool. Social network theory (SNT) (Daly, 2010) promotes the use of mapping to deepen the understanding of one's perceived group connections. However, there is no standard process to create such social network maps (SNMs). Further, SNMs are often created by researchers rather than participants. We address these gaps by applying SNT (Daly, 2010) to develop a mapping tool for TLs to create their own SNM in relation to their district-based leadership project. We facilitated the development of SNMs supporting TLs to recognize social networks and analyze human capital. Our analysis of these SNMs influenced future professional development sessions, supporting these TLs in leveraging social capital and strengthening leadership skills. Our results have implications for future research on self-created SNMs and the use of SNM as a professional development tool.

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

Supporting Teachers' Understanding and Infusion of Culturally Responsive and Anti-Racist Teaching in Science

Shannon Davidson*, University of Alabama, USA
Roxanne Hughes, Florida State University, USA
Stacey Hardin, University of Washington, USA

ABSTRACT
Research Experiences for Teachers (RET) programs can be fruitful professional development contexts for science teachers to support and further their understanding of science and the community of science but have not often included opportunities for science teachers to engage critically with issues of equity and systemic oppression that influence the disciplines of science and K-12 science spaces. With this oversight comes the danger that teachers' experiences within RET may unintentionally reinforce stereotypes situated in exclusionary and deficit-based narratives about "who belongs" in science and "whose ideas count" as scientific. To this end, this work-in-progress study aims to examine the learning and experiences of RET participants who took part in an RET program designed to support teachers' science pedagogy while also bridging and critically interrogating their teaching through the frameworks of Culturally Relevant Pedagogy and anti-racist teaching practices. Drawing on semi-structured interviews occurring post-participation, as well as teacher reflections and interactions during the program, we anticipate this work will offer productive insights into the fruitfulness of professional development efforts that expose teachers to the professional science community of practice while supporting teachers to interrogate unjust aspects of the discipline and incorporate culturally relevant and anti-racist teaching practices into their own practice.

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

Longitudinal Studies of In-Service Teacher Education: A Discussion of Methods

Chris Pavlovich*, Montana Technological University, USA
Rayelynn Brandl*, Montana Technological University, USA

ABSTRACT
This roundtable discussion centers on broader impacts and methodologies for longitudinal measurement, dissemination of lessons learned, and collaborations. Beyond the immediate, reportable measures of in-service teacher grants and goals, what are the measurable, long-term, broader impacts of this work? Grant proposals require projections of broader impacts, yet immediate reporting is rife with limitations for methodologies targeting long-term impacts. This roundtable discussion is focused on the measurement and dissemination of broader impacts of in-service models. An additional goal of the discussion is to assist grant proposal work in the arena of broader impacts. A collaborative roundtable discussion aids the authors' process, yet the larger picture of these poignant questions are aimed to engage members meaningfully in their own work on varied scales of time and proportion. How can looking back with appropriate tools of reflection help us move forward in research for science teaching?

Strand 10: Curriculum and Assessment
Work-in-progress Roundtable

How Does the Framing of Anchoring Phenomena Affect Student Perception of Interest and Relevance?

Zoe Buck Bracey*, BSCS Science Learning, USA

Jamie Noll*, BSCS Science, USA
Diego Rojas-Perilla*, BSCS Science Learning, USA
Joe Kremer*, Denver Public Schools, USA

ABSTRACT
Developers applying NGSS-aligned instructional models often use student data from national surveys to make decisions about anchoring phenomena. But there is a lot we don't know about how to interpret data from these surveys. In particular, we know very little about how the framing of phenomena impacts students' self-reported interest, and/or students' perceptions of relevance, and if/how student identity moderates this relationship. We have designed a research study to address these gaps in what we know and help disentangle interest from relevance in our interpretation of survey data. We are interested in how framing phenomena either in a local context, as an engineering problem, or by highlighting related social/environmental injustices affects students' perceptions of relevance/interest. We are also interested in investigating the effect that gender/racial identity might have on this relationship. We propose to carry out this study over the next six months and present the results at a NARST work-in-progress round table next spring.

Strand 7: Pre-service Science Teacher Education
Work-in-progress Roundtable

New STEM Teachers' Experiences: Teacher Preparation, Culture, Identity, and Belonging

Danielle Sodani*, American University, USA
Shari Watkins*, American University, USA
Carolyn Parker*, American University, USA
Kiho Kim*, Washington College, USA
Sarah Belson*, American University, USA

ABSTRACT
This study examines the factors of teacher preparation programs that contribute to STEM teacher candidates' cultural competence, belonging, and racial self-efficacy, which may ultimately lead to persistence and retention in the STEM teacher workforce. As part of an ongoing study, the project team is investigating how the quality of Research-Practice Partnerships – collaborations of school systems and university faculty to support Noyce Scholars through their preparation and induction – can be assessed to measure the influence teacher preparation programs can have on the persistence and retention of teachers in schools located in historically resilient communities. Data sources for this study include survey research, interviews, and case study approaches. This study shares the preliminary results of a survey designed to collect retention data, demographic identity data, information about Scholars' cultural competence, belonging, and racial self-efficacy, and profiles about their preparation, mentoring/induction, and professional experiences with the goal to receive feedback from NARST attendees to inform survey findings and research approaches.

Strand 7: Pre-service Science Teacher Education
Work-in-progress Roundtable

Preservice Teachers' Facilitation of Argumentation: Exploring Their Attention to and Perceived Complexity of Students' Thinking

Meredith Park Rogers*, Indiana University, USA
Taiwo Ogundapo*, Indiana University, USA
Esther Namakula*, Indiana University, USA
Kady Lane*, Indiana University, USA
Dionne Cross Francis, University of North Carolina - Chapel Hill, USA
Pavneet Kaur Bharaj, CSU-Bakersfield, USA
Weverton Ataide Pinheiro, Texas Tech University, USA
Adam Maltese, Indiana University, USA
Jamie Mikeska, Educational Testing Service, USA
Calli Shekell, Thiel College, USA

ABSTRACT
High quality instruction relies on the teacher understanding students varied thinking and considering how to select, sequence, and connect ideas to facilitate productive discussions. Teacher preparation programs, however, often struggle to provide preservice teachers with authentic opportunities to rehearse components of such a complex practice. This study seeks to examine how 11 preservice teachers are attending to students' ideas while conducting a 30-minute simulated argumentation-focused discussion. These sessions were video-recorded and analyzed using a rubric. The PSTs were also asked to rank and provide reasons for the rankings regarding the complexity of each student avatar pairs' thinking. The PSTs reasoning was thematically analyzed. All but one PST scored as well-prepared to attend to students' ideas during their facilitation of the discussion. Also, the PSTs collectively ranked two pairs of student avatars thinking as equally complex and scored the other two pairs much lower in complexity. This work in progress will further explore if there is a potential relationship between attending to and perceived complexity of students' thinking during argumentation-focused discussions.

Strand 7: Pre-service Science Teacher Education
Work-in-progress Roundtable

Exploring the Use of Model Eliciting Activities to Promote Quantitative Reasoning Among Preservice Teachers

Cynthia Lima*, University of Texas at San Antonio, USA

ABSTRACT
This study explores using an instructional sequence based on Model Eliciting Activities to foster quantitative reasoning among a group of 20 bilingual elementary preservice teachers. The implementation worked collaboratively to solve two activities as part of a Science Methods Course. The qualitative analysis of participants' artifacts revealed that the activities allowed abstracting variables and establishing mathematical relationships among energy-related variables. They also provided access to the complex mathematical concepts underlying each phenomenon.

Strand 7: Pre-service Science Teacher Education
Work-in-progress Roundtable

Laying the Foundation for Translanguaging Pedagogy in Preservice Secondary Science and Math Teacher Preparation

Edward Lyon*, Sonoma State, USA
Caroline Spurgin*, Sonoma State, USA
Lyn Scott, Cal State East Bay, USA
Michele Korb*, Cal State East Bay, USA

ABSTRACT

There is a growing body of research around preparing secondary preservice teachers (PSTs) to support multilingual learners as well as research unpacking what it looks like for science teaching to allow and support emergent bilinguals in moving fluidly among their own linguistic sense making resources (i.e., translanguaging). Our study integrated these two areas. Math and science method instructors collaborated with biliteracy and translanguaging scholars to develop, refine, and study a model of secondary teacher preparation at two universities in the Western United States. We asked "what teaching practices and teacher education pedagogies were observed in the participating secondary method courses both in the initial planning year and during the first implementation year?" Through a multiple case study design, we observed how each method instructor engaged PSTs in high levels of multiple teaching practices as measured through a project-developed observation rubric. Although specific attention to translanguaging was still limited in ways, we observed a set of foundational pedagogies that could serve as building blocks as method instructors more easily shift in stance and design toward incorporating translanguaging in their method courses. The contribution here is a pathway for better ensuring the preparation of PSTs to support multilingual learners.

Strand 7: Pre-service Science Teacher Education
Work-in-progress Roundtable

Examining the Dimensionality of NGSS Learning Objectives Generated by Preservice Elementary Teachers

Lin Xiang*, University of Kentucky, USA
Corinne Lardy*, California State University, Sacramento, USA
YoungJin Song*, California State University, Long Beach, USA
Michele Korb*, California State University, East Bay, USA
Hui-Ju Huang*, California State University, Sacramento, USA

ABSTRACT

This presentation reports analyses on NGSS learning objectives (LOs) constructed by preservice elementary teachers in science methods courses at three universities working together as part of a larger Networked Improvement Community to improve instruction in NGSS for preservice teachers. The authors analyzed 86 LOs from 57 science units to identify the characteristics of the LOs preservice elementary teachers generated when planning a mini science unit and evaluate how the three NGSS dimensions (SEP, DCI, and CCC) were

included in these objectives. We have found DCIs were the most commonly included dimension, identified in 97% of the LOs, followed by SEPs and CCCs, identified in 85% and 77% of the LOs, respectively. When examining individual LOs, we found only 7% of the 86 LOs were one-dimensional, 30% were two-dimensional, and 61% included all three dimensions. When examining LO sets based on each science unit, we found up to 74% were three-dimensional. Although it is encouraging that many preservice elementary teachers can integrate multiple NGSS dimensions into LOs, we noticed 77% of identified CCCs were implied rather than explicitly stated in LOs. Participants in this round-table session will have the chance to examine and discuss sample objectives from this analysis.

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

"You Can't Take for Granted That Kids Know That!": Centering Teacher Learning Around Equity Supports

Jennifer Jackson*, The Pennsylvania State University, USA
Scott McDonald, The Pennsylvania State University, USA

ABSTRACT
Using qualitative methods, this study seeks to understand the impact of a professional learning environment on teacher learning to examine communication that occurs between the teacher participants, specifically when thinking about ways to support students in the classroom. The problem that this study addresses is the lack of diversity in the teacher education workforce vs. the demographic shift amongst the student population, especially amongst Black and Brown students (Butler et al., 2014). Now, at the present time, due to there being a mostly white teacher workforce in relation to the increasing number of Black and Brown students, teachers need to be prepared to teach BIPOC students. To do this, teachers need to receive professional development on how to attend to language use and responsiveness in the classroom through the creation of supportive questioning. For this study, several major data sources were collected which include, but are not limited to video and audio recordings. In addition, after the PD, we conducted semi-structured teacher interviews with 9 of the PD participants. By applying the theory of Professional Vision, this study will answer the following question: How do secondary science teachers negotiate supportive questioning for students while examining an online Earth science curriculum?

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

Unlocking Potential: Navigating Universal Design for Learning in Elementary Engineering for Diverse Learners

Bree Jimenez*, The University of Texas Arlington, USA
Ginevra Courtade, University of Louisville, USA
Mary Elliott, University of Louisville, USA
Jennifer Fosbinder, University of Louisville, USA

ABSTRACT
This presentation highlights research from Project BEES, NSF DRK-12 funded research, examining the intersections of special education, engineering pedagogy, and Universal Design for Learning (UDL). Students with disability and extensive support needs (ESN) are underserved by current practices and are often not responsive to typical science/engineering instruction. Our research focuses on the complex dynamics of teaching engineering to students with ESN, investigating the impact of professional development (PD) on teacher self-efficacy, and uncovering teachers' strengths and limitations of embedding principles of UDL in elementary engineering education.
Six teachers of students with ESN implemented the Youth Engineering Solutions (YES!) curriculum (Cunningham, 2021) while participating in PD to support their understanding of engineering instruction. Qualitative data were collected using focus groups, semi-structured interviews, observations, implementation logs, and self-efficacy surveys. Line-by-line coding and thematic analysis were used to analyze data. This presentation highlights preliminary results regarding teachers' perceptions of PD and engineering instruction over time. This roundtable will engage participants in a dynamic dialogue, inviting collaborative insights, methodological reflections, and suggestions for further exploration. By offering a preliminary glimpse into our ongoing qualitative investigation, we anticipate enriching the discourse surrounding special education, engineering pedagogy, and UDL in the context of elementary education.

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

Engaging with Science Educators through Flipped Observations to Support Enactment of Social Justice Practices

Felisha Dake*, Oregon State University, USA
Cory Buxton, Oregon State University, USA
Melissa Livingston, Oregon State University, USA
Karla Hale, Oregon State University, USA

ABSTRACT
STEM education researchers and educators continue to grapple with strategies to broaden student participation and accessibility to science. This is made more difficult by the divide between theory and practice that often alienates educators and students from the research process. This study is situated in a research-practice partnership that uses design-based implementation research to engage educators, students, and communities through direct involvement as collaborators in professional learning. The proposed pedagogical model introduces a framework of practices and tools supporting language, culture, and knowledge-building through science to support educators' agency to take up the practices that best meet their students' needs, which we term multiplicities of enactment. This model builds on the Next Generation Science Standards to better support connections to social justice and students' communities. This project introduces a flipped observation protocol to support educators in developing a better understanding of the tools and practices through their enactment of two science model lessons in their after school STEM clubs, with the goal of developing educators' contemporary perspectives on language and science learning. Initial

findings demonstrate that educators are beginning to show more critical attention to language practices while also prioritizing practices most consistent with their interests and backgrounds.

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

Supporting Teachers in Developing and Using Data Literacy Skills Through Research Experience for Teachers Program

Amanda Morrison*, Oregon State University, USA
MIchael Giamellaro, Oregon State University, USA

ABSTRACT

Prior research on science teacher professional development in the context of research experiences for teachers and data literacy is limited. It is not known how teachers engaging in this type of professional development gain data literacy skills and if those skills are transferable to curriculum development. Using a qualitative case study research approach consisting of lesson plan documents and teacher interviews, this exploratory study seeks to discover the aspects of data literacy professional development most useful in lesson plan development for U.S. middle and high school teachers participating in a 2 year research experience for teachers program spanning three long-term ecological research sites. While this study is still in progress, data collection will occur in Fall and Winter 2023 with data analysis beginning in February 2024. The findings will be of interest to those designing professional development in which teachers and scientists are collaborating in research experiences to enhance teacher understanding of the nature of science.

Strand 8: In-service Science Teacher Education
Work-in-progress Roundtable

Effective Engineering Education for Elementary Multilingual Learners: A Conceptual Framework for Transformative Professional Learning

Jerome Shaw*, University of California, Santa Cruz, USA

ABSTRACT

The Next Generation Science Standards call for educators to incorporate the teaching of engineering with science instruction in K-12 classrooms in the United States. A sizable portion of students in those classrooms come from backgrounds in which English is not the first or native language; i.e., English Learners (ELs) – more positively known as Multilingual Learners or MLs. However, studies have documented (a) the lack of engineering teaching occurring in elementary classrooms, (b) elementary teachers' expressed lack of preparation for teaching engineering, and (c) elementary teachers' expressed lack of preparation for teaching ELs. Our project is developing a model of teacher professional learning designed to enhance elementary teachers' understanding of and capacity to effectively engage in (a) the teaching of engineering, (b) teaching multilingual learners in general, and (c) teaching engineering to multilingual learners in particular. We have produced an initial version of a conceptual framework (CF) that provides project staff with a summary of literature-based understandings of key topics related to the project's overarching goal. The CF is a living

document that will be revised throughout the course of the project. We propose to engage with interested colleagues to solicit feedback to inform future versions of this CF.

Strand 10: Curriculum and Assessment
Roundtable

Stemtelling: Learning Science and Building Epistemic Communities Through Storytelling

Jenny Tilsen*, University of Minnesota, USA

ABSTRACT

Storytelling is a method for improving science education towards engaging multiple epistemologies and diverse perspectives in science. However, little research exists on the impact of creating and sharing personal narratives when students center their own socio-cultural knowledge to learn science and work towards building epistemic communities. This qualitative study explores how students enrolled in an undergraduate field course use an emerging storytelling tool to learn science. By positioning scientific knowledge as socially situated through the project tool, participants learn science through creating and sharing stories in an epistemic community. Findings from this study will further inform the development of the project tool as an inclusive storytelling-based pedagogical tool in science learning and practice spaces.

Strand 10: Curriculum and Assessment
Roundtable

The Impact of Ungrading on Secondary Physics Students' Self Determination

Christopher Sarkonak, Crocus Plains Regional Secondary School, Canada
Ellen Watson*, Brandon University, Canada

ABSTRACT

For years, educators and educational researchers have called for reconsideration of traditional grading systems, yet these systems remain largely unchallenged in most secondary science classrooms. This presentation explores the impact of one high school physics teacher's shift to "ungrading". Ungrading describes the movement aimed at removing the focus on grades as the single indicator of learning. Despite other teachers' claims of "learning-loss" because of COVID interruptions, this classroom teacher continued to see an increase in students entering and successfully completing secondary physics courses. Was ungrading motivating students to learn physics? Open-ended, written surveys from the beginning and end of class, as well as written midterm and final self-grading reflections, were collected for 24 students registered in this teacher's physics courses during the 2022-2023 school year. Data was analyzed using thematic analysis through a well-defined theoretical framework describing motivation: self-determination theory. Self-determination theory focuses on three basic needs to be met to satisfy interest, development, and wellness: autonomy, competence, and belonging. Findings indicate that students perceived autonomy and competence increased because of the ungrading approach. Adding to the thin empirical evidence about ungrading, this study offers insight into the benefits of ungrading in secondary physics classrooms.

Strand 10: Curriculum and Assessment
Roundtable

The State of Framework-aligned Assessment Tasks: Where are we?

Clarissa Deverel-Rico*, BSCS Science Learning, USA
Patricia Olson, BSCS Science Learning, USA
Cari Herrmann Abell, BSCS Science Learning, USA
Chris Wilson, BSCS Science Learning, USA

ABSTRACT

The emphasis on an equitable vision of science learning in current science education reform efforts sees students as contributing to knowledge-building through drawing on their rich cultural and linguistic backgrounds while engaging in the three dimensions to make sense of compelling, relevant phenomena. However, this vision will not be fully realized without coherence between curriculum, instruction, and assessment. As a majority of states have now adopted standards aligned to or adapted from the Framework, we see an urgent need for assessments that can support rather than conflict with promoting equitable science learning. In this study, we seek to understand the current state of Framework-aligned classroom assessment tasks. We have amassed 339 middle school tasks, originating from state-level assessment banks and university- or research group-developed tasks. Our preliminary findings from characterizing 104 tasks revealed that the majority of tasks target dimensions of the NGSS or Framework-based standards and include a phenomenon. However, there are challenges in framing phenomena that attend to students' interests and identities and engage students in three-dimensional sensemaking. Additionally, some phenomena are not based in real-world observations and are not authentic from students' perspectives, resulting in difficulty for students to make connections of local or global relevance.

Strand 10: Curriculum and Assessment
Work-in-progress Roundtable

The Grand Challenges Project: Co-Developing an International Interdisciplinary SSI-Based Science Curriculum

Keren Dalyot*, Weizmann Institute of Science, Israel
Nannan Fan, University of North Carolina at Chapel Hill, USA
Heewoo Lee, University of North Carolina at Chapel Hill, USA
Rebecca Lesnefsky, University of North Carolina at Chapel Hill, USA
Shira Passentin, Weizmann Institute of Science, Israel
Natasha Segal, Weizmann Institute of Science, Israel
Zhen Xu, University of North Carolina at Chapel Hill, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA
David Fortus, Weizmann Institute of Science, Israel

ABSTRACT

The Grand Challenges (GC) project aims to tackle some real challenges - both for science education and for society. The COVID pandemic highlighted how our daily lives are

dependent upon issues and decisions that are informed by science. Yet science education, even after decades of discussions about science literacy and its relation to science in daily lives, typically fails to represent this to students. It is a challenge to restructure science education so that students have opportunities to see the relevance of science to their lives. Aiming to address this, we set on a mission to develop a unique middle school science curriculum. Rather than attempting a survey of principles in each discipline as is typical in middle school science, we focused on ideas that are critical for understanding the GC of the world that students are set to inherit. Moreover, we focused on middle school, as this age has been identified in many studies as a critical age where students tend to lose their interest in science. The goal of our proposed roundtable presentation is to present the development process of these units by a multicultural, multinational, and multidisciplinary team, as well as the research that will accompany the implementation.

Strand 8: In-service Science Teacher Education

Roundtable

Empowering Science Teachers' Pedagogical Transformation through Participation in an Online Asynchronous Graduate Program

Elizabeth Saville*, UBC Okanagan, Canada
David Anderson, UBC, Canada
Marina Milner-Bolotin, UBC, Canada

ABSTRACT

This qualitative study uses Fullan's Theory of Educational Change (2007) to explore how an asynchronous online graduate program in science education might support pedagogical shifts for practicing science teachers. The objective of this research was to gain educators' perspectives on how their engagement and participation in an online science education cohort-based graduate program impacted their ongoing pedagogy, understanding, and pedagogical attitudes. Three significant themes emerged from the data collected through focus groups revealing how participants (n=25) understood the graduate program to impact them through (1) Exploring science education and gaining valuable insights about teaching and learning in ways that (2) Shifted pedagogical paradigms, inspiring confidence, resilience, and self-reflection. In turn, these paradigm shifts were instrumental in (3) Empowering pedagogical transformation both within and across their educational contexts. This research offers additional and complementary findings to those from studies that focus on how to foster pedagogical transformation through online graduate programs. Findings may assist individuals engaged in developing online graduate programs by highlighting the significant effects of asynchronous online programs on educators' pedagogical understandings and attitudes. Furthermore, this information can further inform the advancement of online graduate programs aimed at fostering pedagogical transformation for science educators.

Publications Advisory Committee
Sponsored Session
NARST/NSTA Annual Research Worth Reading Recognition
19-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 16

NARST/NSTA Annual Research Worth Reading Recognition

ORGANIZERS
Lindsay Lightner, Washington State University Tri-Cities, USA
Tina Vo, University of Nevada, Los Vegas, USA
Emily Dare, Louisiana State University, USA
G. Michael Bowen, Mount Saint Vincent University, Canada
Shiang-Yao Liu, National Taiwan Normal University, Taiwan
Deborah Hanuscin, Western Washington University, USA

ABSTRACT
Join us in congratulating this year's recipients of the NSTA Annual Research Worth Reading award. This award is given to three research groups whose 2022 JRST articles inspire excellent teaching innovations. Each recipient will briefly highlight the broader practical implications of their work, followed by a joint discussion. This year's recipients are:

Peters_Burton, E., Rich, P. J., Kitsantas, A., Stehle, S. M., & Laclede, L. (2023). High school biology teachers' integration of computational thinking into data practices to support student investigations. Journal of Research in Science Teaching, 60(6), 1353-1384. https://doi.org/10.1002/tea.21834

Visintainer, T. (2023). Teaching health justice and reimagining narratives of place through community_driven science practices. Journal of Research in Science Teaching, 60(8), 1817-1852. https://doi.org/10.1002/tea.21857

Grapin, S. E., Haas, A., Llosa, L., Wendel, D., Pierson, A., & Lee, O. (2023). Multilingual learners' epistemologies in practice in the context of computational modeling in an elementary science classroom. Journal of Research in Science Teaching, 60(9), 1998-2041. https://doi.org/10.1002/tea.21850

Strand 1: Science Learning: Development of student understanding
Related Paper Set
Science Learning Progression Research: Insights, Challenges, and Future Directions
19-Mar-24, 8:15 AM-9:45 AM
Location: Directors Row E

Learning Progression in Genetics
Ravit Duncan*, Rutgers University, USA
Moraima Castro-Faix, Rutgers University, USA

ABSTRACT
This paper tells the evolution story of a genetics LP from its initial conception in 2009 through its revision over the course of multiple implementation studies. The LP informed the Framework for K-12 Science Education conceptualization of the Heredity Disciplinary Core Idea (LS3) and its development over grades and grade bands (NRC, 2012). Our aim is to highlight some of the challenges and lessons learned from our decade-long research agenda of refining a LP that can inform standards, curriculum, and assessment in the domain of genetics.

Learning Progressions for Energy in Physical Sciences
Jeffrey Nordine*, University of Iowa, USA
David Fortus, Weizmann Institute of Science, Israel

ABSTRACT
The traditional approaches to energy instruction focus on the identification of different forms of energy and the transformations occurring among them. Although many researchers have questioned whether the conceptual foundations of these form-based approaches may be responsible for students' difficulties (Brewe, 2011; Ellse, 1988; Authors, 2011; Swackhamer, 2005), little has been done to investigate this matter (Authors, 2018). This paper contributes to filling this knowledge gap by introducing a non-traditional approach to energy instruction, called the system-transfer approach (STA), in the context of LP research. We elaborate how this STA LP will help students learn energy productively in physics classrooms. Our research provides important implication on teaching energy in physics, as well as future LP research that uses unconventional instruction to help students progress.

Geology & Earth Systems Sciences Learning Progressions
Richard Duschl, Southern Methodist University, USA
Scott McDonald*, Penn State University, USA

ABSTRACT
The emergence and development of the Theory of Plate Tectonics is a story of international teams of scientists discovering, measuring, and coordinating a set of physical, chemical,

biological, geologic, oceanographic, and atmospheric patterns that occurred over hundreds of millions of years on the Earth. The recent 20th century development of new technologies and tools made it possible to observe and measure unforeseen Earth dynamics and patterns. These two LPs are examples of how new conceptualization of Earth System Science and new technology used into Earth System Science can be incorporated in K-12 science education. We also discuss future directions of LPs in geo/geographical sciences.

Developing Three-Dimensional Learning Progressions of Energy, Interaction, and Matter at Middle School: A Design-Based Research

Namsoo Shin*, Michigan State University CREATE for STEM Institute, USA
PENG HE*, Michigan State University CREATE for STEM Institute, USA
Joseph Krajcik, Michigan State University CREATE for STEM Institute, USA

ABSTRACT

Using a design-based research approach, this study put efforts into developing a 3DLP of matter, interaction, and energy at the middle school level and presents the essential design principles for developing 3DLPs. Our chapter offers an illuminating exploration of our design-based research, shedding light on the fundamental design principles and systematic processes involved in developing 3DLPs. By identifying design principles and establishing a systematic process, we unlock new perspectives and approaches to shape the future of designing and implementing 3DLPs to support student knowledge-in-use development.

Learning Progression in Environmental Science

Wendy Johnson*, National Center for Science Education, USA
Emily Scott, Washington State Office of the Superintendent of Public Instruction, USA
Hannah Miller, Vermont State University, USA
Charles Anderson, Michigan State University, USA

ABSTRACT

This paper describes how learning progressions were used to support the development of curriculum and assessments leading toward the goal of environmental science literacy—proficiency in using scientific data and models to act as informed citizens and prepare for future learning—for middle and high school students. Two learning progressions were developed in the context of the XXXX research project. They focus on how students developed proficiency in (a) tracing matter and energy through investigations about plant and animal growth, burning, and decay, (b) explaining these phenomena in terms of cellular and atomic-molecular mechanisms, including photosynthesis, biosynthesis, digestion, cellular respiration, and combustion, and (c) 'preparing for future learning' (Bransford & Schwartz, 1999) about new phenomena and socio-scientific issues. We used them to develop curriculum and assessments. Our research provides important implications for the whole process from learning progression development to implementation of learning progression based curriculum and assessment in classrooms.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
Identity and Diversity
19-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 11

Science Identity Development Across Multiple Spatial Configurations: A Narrative Inquiry Project
Alison Happel-Parkins*, University of Memphis, USA
Katherine Ayers*, St. Jude Children's Research Hospital, USA
Olayinka Mohorn-Mintah*, University of Memphis, USA

ABSTRACT
Lack of diversity in biomedical careers is intertwined with persisting issues of science, technology, engineering, math, and medicine (STEMM) education equity. While providing access and opportunity for research experiences is an important equity endeavor, a focus solely on broadening participation neglects the role of institutions in perpetuating hegemonic views of science and who can be a scientist (Kayumova and Dou, 2022). To better understand the intersectionality of science identity, there is increased interest in the research community on conceptualizing identity as a lived experience, highlighting the importance of attending to (mis)recognition and the situational contexts where science identity develops (Avraamidou, 2020). To do this, we draw on Massey's (2005) conceptualization of space as a dynamic and relational entity that shapes and is shaped by social practices. Findings demonstrate the way that radicalized views of who can be a scientist and whose ideas matter in science work at the systems level to expand or contrast Travis' future trajectories. These findings highlight the need to attend to the role of spatial configurations in science identity development and how spatial configurations relate to (mis)recognition.

Minoritized High Schoolers' Perceptions of Science and Scientists
Jennifer Tripp*, University at Buffalo, SUNY, USA
Noemi Waight, University of Buffalo - SUNY, USA
Xiufeng Liu, University at Buffalo, SUNY, USA

ABSTRACT
The purpose of this qualitative case study is to document the perceptions of science and scientists among racially, ethnically, and linguistically minoritized ninth graders at an urban inclusive, STEM-focused high school (ISHS) in a mid-sized, northeastern city in the United States, along with the contexts and experiences informing these perceptions. Iterative cycles of inductive and deductive coding and domain analysis revealed main themes. Students viewed science as (1) a body of knowledge, (2) testing and experimenting, (3) a life-enhancing discovery, (4) researching and building on background information, and (5) connected with other disciplines and everywhere. Their perceptions of scientists were stereotypical and expansive, including that scientists are (1) smart and serious, (2) use science equipment and gear, and are (3) creative, curious, and open-minded. While students primarily identified

stereotypical, deceased White scientists, three girls of color mentioned counter-stereotypical scientists. Science field trips and after school programs, as well as science in the media and school, informed students' perceptions. These findings contribute to the ISHS literature, which to date has not documented minoritized students' perceptions of science and scientists. Implications for teaching, learning, and research related to building on and extending these views in more critically conscious ways, are provided.

Not the Only Novice in the Room: Partnership and Belongingness in a Research Immersion Program

Robyn Pennella*, St. Jude Children's Research Hospital, USA
Katherine Ayers, St. Jude Children's Research Hospital, USA
Olayinka Mohorn-Mintah, University of Memphis, USA
Summer Jasper, St. Jude Children's Research Hospital, USA
Susan Nordstrom, University of Memphis, USA

ABSTRACT
Lack of access to STEMM mentors has been identified as a barrier to biomedical research careers, leading to a lack of diversity in this field. To address such a barrier, the National Institutes of Health invested funds to support institutions in developing research immersion programs to provide "underrepresented" students with mentored research experiences. While providing access to research experiences is an important endeavor, a focus solely on broadening participation neglects the role of institutions in perpetuating hegemonic views of science. Institutions often fail to recognize how entanglements of affect and emotion shape experiences in these programs and work to (de)legitimize a sense of belonging in science and perpetuate the notion of science as for an exclusive few. Here we describe findings from a project aimed at understanding the entanglement of emotion and affect in a research immersion program and how these entanglements shaped participants' sense of belongingness in the program and research more broadly. Drawing on Jaber and Hammer's (2016) epistemic affect, Ahmed's (2014) cultural politics of emotion, and Massey's (2005) Space, we come to understand how individual histories and emotional experiences with stereotypes work at the meta-affective level to contract feelings of belongingness in science.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
SC-Organized Paper Set
Teacher Learning
19-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Court 1

Comparison of an AI Professional Development Program's Impact on Science and non-Science Teacher AI Literacy

Katherine Moore, MIT STEP Lab, USA
Phylis Wilson*, Richmond Public Schools, USA
Helen Zhang, Boston College, USA

Irene Lee, MIT STEP Lab, USA

ABSTRACT
In the face of the rising prevalence of artificial intelligence (AI) in daily life, there is a need to integrate lessons on AI literacy into K12 settings to equitably engage young adolescents in critical and ethical thinking about AI technologies. This exploratory study reports findings from a teacher professional development project designed to advance teacher AI literacy in preparation for teaching an AI curriculum in their inclusive middle school classrooms. Analysis compares the learning experiences of 30 participating teachers (including Computer Science, Science, Math, English, and Social Studies teachers). Results suggest Science teachers' understanding of AI concepts, particularly logic structures, is on average higher than their non-Science teacher counterparts. Teacher interviews reveal several thematic differences in Science teachers' learning from the AI PD as compared to their counterparts, namely learning from reflective discourse with diverse groups. Findings offer insights on the depth and quality of Science teacher AI literacy after participating in an AI teacher PD, with implications for future research in the integration of AI education into Science teachers' inclusive K12 classrooms.

A Longitudinal Study of Teacher Leadership Identity Development
Christine Lotter*, University of South Carolina, USA
Jan Yow, Unversity of South Carolina, USA
Denae Kizys, University of South Carolina, USA
Latrice Jones, University of South Carolina, USA

ABSTRACT
This paper investigates rural science and mathematics teachers' leadership development over a six-year teacher leadership professional development program. The 20 participants, three males and 17 females, had an average of 16.5 years of teaching experience at the beginning of the program. Twelve teachers self-identified as White and eight as Black. The teachers (Master Teaching Fellows-MTFs) were interviewed four times: (a) before entering the program (Fall 2014), (b) in Spring 2016, (c) in Fall 2018, and (d) in Spring 2020. The interviews were audio recorded and transcribed for analysis using a constant comparative method (Bogdan & Biklen, 1998). The teachers' leadership identity developed across four main areas: 1) beliefs (efficacy and growth-mindset), 2) dispositions (adaptive/innovative, other-focused, action-oriented); 3) activities (leadership roles, supporting learning of peers and students, dissemination, etc.); and 4) positionality (collegial, facilitator, and power). Throughout our six-year program, the MTFs gained teacher leadership efficacy and broadened their conceptions of teacher leadership and their teacher leadership identity. As they gained content and pedagogical knowledge, resources, networking skills through conferences, and coaching and mentoring skills, they described themselves as a voice for others, more action-oriented and flexible and able to support the learning and social well-being of their peers and students.

Conceptualization and Development of an Instrument for Exploring the Metacognition of Junior High Science Teachers

Gamolnaree Laikram, The Institute for the Promotion of Teaching Science and Technology, Thailand
Gregory Thomas*, University of Alberta, Canada

ABSTRACT

The development and enhancement of science students' metacognition, their knowledge control and awareness of their science learning processes, continues to be attended to within science education. It is well established that improving students' metacognition can assist them improve their understanding of science and the cognition employed by scientists. However, research into the science teachers' metacognition is not prominent in the literature and current research is establishing links between the nature of science teachers' metacognition and the extent to which they support the development of metacognitively oriented science classroom learning environments. Therefore, means of exploring science teachers' metacognition in relation to their science-specific learning processes are required. This study, conducted in Thailand, reports on the conceptualization and development of a quantitative survey instrument that can be used as one of a battery of measures for exploring science teachers' metacognition. Pilot testing of an initial 38-item instrument with 26 participants led to a study with 214 participants. Data collected were analysed using statistical methods involving Reliability and Rasch analyses. These analyses resulted in a final, 27-item instrument that used a 5-point Likert system and consisted of two sub-scales; metacognitive knowledge, and regulation. The potential use of this survey is outlined.

Exploring Science Teachers Sensemaking of Generic Equity-focused Professional Development

Matt Stewart*, University of Washington, USA

ABSTRACT

Many science teachers work to be equitable in their classes to support student learning. Teachers learn about equity-focused practices from a variety of contexts and must translate those into their pedagogy. This research study explores science teachers' practices to teach more equitably and which messages get taken up from professional development. I address the question, How do science teachers make sense of generic equity-focused professional development within their science specific teaching context? This research uses qualitative case studies based on interviews and classroom observations of five science teachers who work together in a public high school. Findings show that teachers took up generic instructional approaches towards more equitable classes. They foregrounded relationships with their students, maintained attitudes towards flexibility in their practice to accommodate students' needs, and centered students' ideas through discussion and student choice. These approaches can be traced to the whole-school equity-focused professional development. The teachers continue to question what equitable and culturally relevant science teaching looks like.

Framing the Game: Teachers' Perspectives of Varied Epistemological Framing
Christine Hirst Bernhardt*, University of Maryland, USA
Janelle Bailey*, Temple University, USA

ABSTRACT
This study delves into the complex landscape of teachers' cognition through epistemological framing and impacts upon student engagement with science practices. Epistemological framing is the interpretive lens guiding acceptable forms of interaction, and plays a critical role in students' classroom participation. Science teachers must navigate the balance between framing for prescribed curriculum and framing for students to build valued knowledge, as implied by reform efforts. This study unveils teachers' perspectives and rationales as they navigate these tensions. The study employs qualitative methods to explore teachers' interpretations of varied framing observed in instructional videos. The research uncovers nuanced themes in how teachers perceive and connect framing while using an NGSS-exemplar activity. The findings underscore the significance of epistemological framing as a cognitive lens to cultivate engaging and responsive pedagogies. By highlighting the interplay between framing, tone, and language, the study emphasizes the need for teacher involvement in framing research and suggests implications for curriculum development and professional learning. The research adds insights to and aligns with interests of NARST members aiming to elevate diverse voices and enhance equitable practices. Ultimately, the study prompts a reevaluation of analytical approaches from skill assessment towards deeper understanding of why teachers adopt particular framing approaches.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Metacognition and Conceptual Understanding in Biology
19-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 17

Using the Inventory of Biotic Climate Literacy: Identifying Target Conceptions for Undergraduate Biology Courses
Emily Holt*, University of Northern Colorado, USA
Sara Gliese, University of Maryland, USA
Gili Marbach-Ad, University of Maryland, USA
Kaci Thompson, University of Maryland, USA
Karen Carleton, University of Maryland, USA

ABSTRACT
While climate change education research in K-12 settings is abundant, studies on college science populations are less extensive. Much existing literature describes interventions targeting this important topic; however, few instruments exist to effectively measure the utility and success of these efforts. We used a new concept inventory, the Inventory of Biotic Climate Literacy (IBCL), to measure undergraduate students' conceptions of the biotic impacts of climate change). Our research asked to what extent do student response patterns

on the IBCL help identify alternative conceptions and target areas for intervention? We administered the IBCL to four biology courses across a biology curriculum in a single US university. First, we established baseline population data. Specifically, pre- and post-IBCL scores were reliable for our sample, and mean post-scores did not differ by class or from pre-scores. Second, our item analysis noted differential patterns by item, suggesting that undergraduates have mastered some concepts, even at the introductory level, and other concepts are not yet mastered by the end of a climate change course. This work helps identify target concepts and areas for intervention development in the future.

Exploring Before Instruction to Improve Conceptual Understanding in Biology
Raina Isaacs*, University of Louisville, USA
Natalie Christian, University of Louisville, USA
Rachel Hopp, University of Louisville, USA
Jeffery Masters, University of Louisville, USA
Linda Fuselier, University of Louisville, USA
Lianda Velic, University of Louisville, USA
Jeffrey Hieb, University of Louisville, USA
Raymond Chastain, University of Louisville, USA
Marci DeCaro, University of Louisville, USA

ABSTRACT
Exploratory learning, an active-learning method in which students explore a novel problem before a lecture, can improve students' conceptual understanding, but not always. We examined whether exploratory learning extends to students' understanding of phylogenetic trees in undergraduate biology courses. We also examined whether simplifying the exploration activity has conceptual benefits. In both Experiment 1 (N=367) and Experiment 2 (N=168), students either completed the learning activity before their regular instruction (explore-first condition) or after (instruct-first condition). Students then completed a posttest that measured their knowledge of definition, concepts, and transfer beyond the taught content. In Experiment 1, the activity included two main activities. Students in the explore- and instruct-first conditions performed equally as well on all posttest subscales (definitions, conceptual, transfer). In Experiment 2, one main activity element was removed, to simplify and help students focus on key elements. Students in the explore-first condition demonstrated higher conceptual understanding compared to the instruct-first condition. Knowledge of definitions and transfer remained equal between conditions. Exploratory learning can benefit conceptual understanding in biology, but instructors must be aware of how taxing the learning materials are in order to find these benefits.

Individual Variation in Undergraduate Student Metacognitive Monitoring and Error Detection During Biology Model Evaluation
Joe Dauer*, University of Nebraska, USA
Mei Grace Behrendt, University of Nebraska, USA
McKenna Elliott, University of Nebraska, USA
Bethany Gettings, Michigan State University, USA
Carrie Clark, University of Nebraska, USA
Tammy Long, Michigan State University, USA

ABSTRACT

Models are a primary mode of science communication and preparing university students to evaluate models will allow students to better construct models and predict phenomena. Model evaluation relies on students' subject specific knowledge, perception of model characteristics, and confidence in their knowledge structures. Fifty first-year college biology students evaluated models of concepts from varying biology subject areas with and without intentionally introduced errors. Students responded with 'error' or 'no error' and 'confident' or 'not confident' in their response. Overall, students accurately evaluated 65% of models and were confident in 67% of their responses. Students were more likely to respond accurately when models were drawn or schematic (as opposed to a box-and-arrow format), when models had no intentional errors, and when they expressed confidence. Subject area did not affect the accuracy of responses. Variation in response patterns to specific models reflects variation in model evaluation abilities and suggests ways that pedagogy can support student metacognitive monitoring during model-based reasoning. Error detection is a necessary step towards modeling competence that will facilitate student evaluation of scientific models and support their transition from novice to expert scientists.

Undergraduate Students' Utilization of Central Dogma Content Knowledge in Argumentation after Problem-based Learning

Katherine Sharp*, Missouri University of Science and Technology, USA
Jeffrey Chalfant, University of Kentucky, USA
Rebecca Krall, University of Kentucky, USA

ABSTRACT

Perceived irrelevance of biochemistry among undergraduate students and future physicians. This perspective may be attributed to traditional course structure lacking explicit real-world situations, which has implications in critical thinking and argumentation skills. This study explores how CBL, a type of PBL, can improve argumentation within biochemistry curricula. Differences in learning outcomes of PBL variations have yet to be considered. The objective of this study to compare the differences in students' argumentation skills after engaging in case-based method to learn the Central Dogma of Molecular Biology in the context of Huntington's Disease (HD), compared to a case-based lecture. This qualitative study utilized a two-tiered system: (1) each response was mapped using the Toulmin's Uses of Arguments as a framework, and (2) a separate coding system allowed for context dependent analysis to determine how content was utilized within students' arguments. Our findings suggest that real-world context support the depth of an argument. Both groups constructed arguments related to the onset of HD. However, the CBL+ group (case-based method) tended to provide increased detail within warrants, compared the CBL- group (case-based lecture).

Strand 6: Science Learning in Informal Contexts
Symposium
Science in the Outdoors: Engaging Teachers and Students in Citizen/Community and Place-based Science
19-Mar-24, 8:15 AM-9:45 AM
Location: Directors Row H

Science in the Outdoors: Engaging Teachers and Students in Citizen/community and Place-Based Science.
Roberta Hunter*, Michigan State University, USA
Gail Richmond, Michigan State University, USA
Rachel Stronach, University of Massachusetts Dartmouth, USA
Hamza Malik, University of Massachusetts Dartmouth, USA
Stephen Witzig, University of Massachusetts Dartmouth, USA
Zion Michal, Bar-Ilan University, Israel
Batzon Nimrod, Bar-Ilan University, Israel
Jadda Miller, University of California Davis, USA
Emma Schectman, University of California, Davis, USA
Heidi Ballard, University of California, Davis, USA

ABSTRACT
Outdoor science education is growing in research and implementation. This symposium brings together four research projects that highlight place-based and citizen/community science education to further understand how these pedagogies are experienced by teachers and students in both rural and urban systems in the U.S. and Israel.

Strand 7: Pre-service Science Teacher Education
Related Paper Set
Conceptualizing and Supporting the Complexities of Science Teacher Noticing
19-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 10

How Preservice Elementary Teachers Notice Opportunities for Equitable Sensemaking in Science
Amanda Benedict-Chambers*, Missouri State University, USA
Carrie-Anne Sherwood*, Southern Connecticut State University, USA

ABSTRACT
This study investigated the noticing of 38 preservice elementary teachers (PSTs) when they used a framework for supporting equitable sensemaking to attend, interpret, and respond to four features of equitable science teaching in their enacted lesson plans. Focusing specifically on the extent to which they noticed each feature in their lesson plan and the

quality of their interpretations, we identified and characterized three levels of noticing (making assumptions; beginning to notice; and noticing explicitness) for each feature. The findings indicate the PSTs brought strengths to noticing explicit ways to design instruction focused on investigating and explaining phenomenon (feature 4) and positioning students as knowers (feature 2), and exhibited some naive assumptions regarding leveraging students' home and life experiences in science learning (feature 3) and ensuring equitable and accessible student engagement and participation (feature 1). These findings offer important insights about the strengths and areas for growth PSTs bring to noticing equitable science instruction.

Pre-Service Science Teachers' Conceptualization of Responsive Teaching

Nessrine Machaka*, University of Illinois at Urbana-Champaign, USA
Christina (Stina) Krist*, University of Illinois at Urbana-Champaign, USA

ABSTRACT

Responsive teaching (RT) is skillfully complex; it requires flexibility and depth of knowledge for noticing the "seeds" of reasoning in students' thinking (Maskiewicz, 2015; Robertson et al., 2016; Watkins et al., 2020). Building on the teacher noticing framework (Jacobs et al., 2010; van Es & Sherin, 2008), noticing has been identified as a mediating factor in RT (Kang & Anderson, 2015). We hypothesize that teachers learn to be responsive by noticing students' thinking and making sense of student/teacher roles in classroom videos. To better understand why pre-service science teachers (PSSTs) would exhibit a particular kind of noticing, we draw on Richards et al.'s (2020) framing-anchored framework. We investigate whether and how PSSTs learn to conceptualize RT goals and practices by examining teachers' noticing as they watch and analyze classroom video clips. Five high school PSSTs were interviewed to reflect on the moments they noticed in light of their science teaching and learning views. We develop coding schemes that characterize what the PSSTs noticed and the factors influencing their conceptualization of responsive teaching. This work informs broader teacher education research and helps teacher educators better understand how PSSTs learn to be responsive, specifically through the practice of noticing in classroom videos.

Approaches to Equity as a Lens to Understand PST's Noticing and Responding

Heather Johnson*, Vanderbilt University, USA
Miray Tekkumru-Kisa*, RAND Corporation, USA
Tara Barnhart*, Chapman University, USA

ABSTRACT

There is increasing interest in supporting PSTs in more expansive noticing through an equity-seeking lens. We sought to understand how PSTs enacted equity approaches in what they noticed and responded to in their analysis of a video clip from a science classroom in a methods course. We analyzed PSTs' video analysis using two equity frameworks to characterize their approaches to equity. Our analysis revealed that PSTs who identified themselves as developing an equity orientation used multiple and overlapping approaches to equity as defined in the NASEM report, namely increasing opportunity and access to high-

quality science and engineering learning and instruction; emphasizing increased achievement, representation, and identification with science and engineering; and expanding what constitutes science and engineering. They also recognized students' intellectual and relational challenges by proposing responses to students' ideas and experiences, changing participation structures, and offering encouragement. This study demonstrated how PSTs reflected on shifts in noticing classroom interactions with an equity orientation, even though they were not explicitly asked to do so. The study provides implications for the design of experiences for PSTs to learn to notice for equity.

Exploring the Noticing Practices of Learning Assistants that Support Formative Assessment in STEM College Courses

Patricia Moreira*, University of Arizona, USA
Young Ae Kim, University of Arizona, USA
Paul Blowers, University of Arizona, USA
Lisa Elfring, University of Arizona, USA
Vicente Talanquer, University of Arizona, USA

ABSTRACT

Students' meaningful learning is fostered by evidence-based teaching practices that engage students in the co-construction of knowledge while receiving prompt and systematic formative feedback. Monitoring and scaffolding students' understanding in large college classrooms is a challenging task. In this context, the incorporation of specialized undergraduate learning assistants (learning researchers) that support the noticing and interpretational processes can help strengthen instructors' formative assessment practices. Our previous investigations have shown that learning researchers (LRs) notice relevant aspects of students' thinking, demonstrating noticing and interpreting skills like those of pre-service teachers. It is expected that these skills improve through specific training. In this study, we explored changes in the perceptions and noticing of five LRs who supported evidence-based teaching in STEM classes over two semesters. Our findings indicated that LRs' perceptions of their role shifted from inferential-evaluative to more inferential-interpretive from one semester to the next. However, LRs' approaches to noticing student thinking showed variability in our sample that suggests that LRs' performance is affected by other factors besides their perceptions about their role. Our study seeks to inform learning assistants programs focused on supporting evidence-based teaching and teachers' training and professional development programs focused on noticing skills.

How Instructional Coaching Supports Noticing for In/equity in the Science Classroom

Janet Carlson*, Stanford University, USA

ABSTRACT

This study uses data collected over a 10-year period from eight cohorts of early-career high school teachers who participated in a two-year professional learning experience (PLE) committed to equitable instructional practices. The PLE for each cohort included two summer institutes and multiple video coaching sessions over two academic years. Teachers recorded their classroom practice and met in video clubs with a coach to reflected on their instruction as well as their students' learning and social interactions. We examined the work of the coaches during the summer institute and coaching sessions for ~200 science teachers to exam how they supported noticing for in/equity. Data include the artifacts from 16 summer institutes illustrating how ideas of equity and social justice were introduced and ~3600 video annotations. Our preliminary findings indicate that teachers rarely call out incidents of inequity in their own classrooms, but are able to see it in other classroom videos or when nudged by a coach. We saw increased uptake of language related to equity and social justice aligned with concepts introduced during the summer institute. In this presentation, we will share the details on the role of an instructional coach in supporting teacher noticing for in/equity.

Teacher Noticing in Appalachia: Context-Specific Knowledge of Place and Community in 5th Grade Teachers' Noticing

Melissa Luna*, West Virginia University, USA

ABSTRACT

Teacher Noticing likely requires a rich and specific teacher knowledge base of the myriad of resources students bring to their science learning. When engaged in Teacher Noticing, teachers need to draw on context specific knowledge of their students, the places they live, and the communities surrounding them. There has been limited research, however, examining the teacher knowledge base noticing draws on. Discussing Teacher Noticing as a process absent its knowledge base limits its usefulness as a construct in understanding teacher practice, especially as a practice employed across different contexts. To that end, this research specifically examines the knowledge base driving Teacher Noticing of nine elementary science teachers in Appalachian school communities. Findings suggest that when actively noticing their students' ideas while assessing students' artifacts, teachers drew on a knowledge base unique to their Appalachian context. For example, teachers drew on knowledge of the outdoor environment—that is, they noticed aspects of students' ideas that were specific to the natural landscape of Appalachia. Teachers also drew on knowledge of their students' community spaces. This poster will expand on these findings and others (with examples) to demonstrate the unique knowledge base of Teacher Noticing occurring in an Appalachian context.

Examining Teacher Noticing and Responding for Cultivating Science-as-Practice

Jennifer Richards*, Northwestern University, USA
Miray Tekkumru-Kisa*, RAND Corporation, USA

ABSTRACT

Emphases on sensemaking and science-as-practice in the field of science education require nuanced ways of noticing and responding to students' contributions in the classroom, but there is much to learn about intersections between noticing and responding. In this poster, we expand our use of a framework for multidimensional noticing for teaching science-as-practice to examine similarities and differences in two experienced middle school teachers' ways of noticing and proposed ways of responding to moments they identify in a classroom video. Analysis of data from video-prompted interviews with the teachers largely showed

consistency across the noticing and responding portions of the interview across all framework dimensions — the foci and disciplinary dimensions they foregrounded and the framings of science learning and student thinking in evidence. Further, it was notable that while both teachers took a resource-oriented perspective toward student thinking, they were oriented to distinct ends in science learning. This highlights the importance of considering multiple dimensions in concert with each other as the field seeks to enrich understandings of science teacher noticing.

How Teachers Leading Professional Development for Peers Support Professional Noticing in Formative Assessment Activities

Hannah Sevian, University of Massachusetts Boston, USA
Rebecca Lewis*, Hingham High School, USA

ABSTRACT

Science teachers who facilitate professional development with peers rely upon their classroom teaching expertise as they lead. Building on models of teacher leadership, through analysis of videos from a yearlong professional development program for mid-career chemistry teachers that was facilitated by teacher leaders, we characterized four modalities of leading from the classroom: Effective Practitioner (application of strong classroom facilitation and presentation skills), Guide (connecting the PD activities to classroom applications), Learning Partner (positioning oneself to learn alongside a participant), and Scholar (illuminating the meaning of an academic model). In this poster, we present findings from analysis of 48 videos of facilitators leading professional development on formative assessment practices and disciplinary noticing, looking at how facilitators relied on the modalities across the year while supporting the growth of their peers' professional noticing. Overall, we found that two modalities (Effective Practitioner and Guide) were more prevalent in the earlier part of the year, used when focusing on operational mechanisms for planning rich tasks and enacting formative assessment in the moment. As the year progressed, facilitators expanded their reliance on the other two modalities (Learning Partner and Scholar) while emphasizing relationships to educational models that can help frame teachers' decision making.

Strand 8: In-service Science Teacher Education
Symposium
Curriculum-Based Professional Development to Support Multilingual Learners: Conceptual Framework, Instruments, and Impacts
19-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 12

Curriculum-Based Professional Development to Support Multilingual Learners: Conceptual Framework, Instruments, and Impacts

Eric Banilower*, Horizon Research, Inc., USA
Scott Grapin, University of Miami, USA
Alison Haas, New York University, USA

Okhee Lee, New York University, USA
Alycia Sterenberg Mahon, Western Michigan University, USA
Courtney Plumley, Horizon Research, Inc., USA
Abigail Schwenger, New York University, USA

ABSTRACT
This symposium will share results from a multi-year project to develop and study the impacts of a curriculum-based PD program integrating science and language with multilingual learners (MLs). The project has three goals. First, we are developing a 2-year PD program to support classroom implementation of a yearlong fifth-grade curriculum integrating science and language with MLs. Second, we are developing and validating the instruments needed to rigorously study the intervention (as well as other NGSS-designed curriculum and PD interventions) and its impacts on teachers and students, especially MLs. Third, we are conducting a quasi-experimental field trial to continue accumulating evidence of the intervention's impacts on teachers' beliefs, preparedness, and instructional practices, as well as student learning. In this symposium, we will present our PD program, instruments, and the impacts of the PD program on teachers during Year 1 of the 2-year intervention.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set
Assessment Development and Validation
19-Mar-24, 8:15 AM-9:45 AM
Location: Directors Row J

Comprehensive Scientific Creativity Assessment: A New Approach for Measuring Scientific Creativity in Secondary School Students

Shiyu Xu*, UCL Institute of Education, United Kingdom
Michael Reiss, UCL Institute of Education, United Kingdom
Wilton Lodge, UCL Institute of Education, United Kingdom

ABSTRACT
This study introduces a Comprehensive Scientific Creativity Assessment (C-SCA) instrument and empirically tests its reliability and validity. While existing instruments to measure scientific creativity generally focus on a single dimension, such as divergent thinking, the C-SCA incorporates scientific knowledge, motivation in scientific creativity and thinking styles within its assessment framework. In this study, the three dimensions of C-SCA were measured using modifications of existing instruments, with the Chinese version of the Creative Trait Motivation (CTM) scale and the Scientific Creativity Test for Upper Secondary School Students (SCT-USSS) both showing good reliability and validity. Furthermore, versions A and B of the SCT-USSS can be used to test the effectiveness of educational interventions on scientific creativity. We incorporated ChatGPT into the scientific creativity scoring process to enhance the objectivity of the scores. Looking ahead, technological advancements hold promise for further improvements in scientific creativity assessment.

Development and Validation of Science Self-Efficacy Survey Scales for Short-Term Intervention

Mikkel Bergqvist*, LIFE Foundation, Denmark

ABSTRACT

In response to the need for tailored impact measurements for a recently introduced science teaching program involving in-school activity and one-day lab events, this study aimed to develop and validate two science self-efficacy scales. The development of the two scales entailed a literature review, which identified three dominant approaches to measuring science self-efficacy. In light of these findings, two scales were developed focusing respectively on specific science topics and generic competencies for conducting experiments. The development of these scales was informed by expert feedback and cognitive interviews with 9th-grade students. A pilot test involving 310 9th-grade students demonstrated high reliability for both scales, statistically validated with Rasch models. These scales, simultaneously relevant to the program's context and scientifically robust, not only serve the specific intervention's evaluation needs but also provide a potential use of the developed scales for broader research contexts. The study underscores the importance of developing impact measures that are relevant to a specific intervention and to validate them scientifically.

Comparing the Draw A Scientists-Test with the Closed Views of Scientists, their Activities, and Locations-Instrument

Bianca Reinisch*, University of Potsdam, Germany
Moritz Krell, Leibniz Institute for Science and Mathematics Education, Germany
Charlotte Schramme, Freie Universität Berlin, Germany
Petra Skiebe-Corrette, Freie Universität Berlin, Germany

ABSTRACT

Assessing students' conceptions about scientists and their work is of central importance in science education. So far, students' conceptions have mainly been collected with the established Draw a Scientist-Test (DAST). This instrument is increasingly criticized in terms of its methodology, which makes its use problematic. Therefore, alternatives were developed, such as the Views of Scientists, their Activities, and Locations (VoSAL)-instrument. The VoSAL-instrument includes the typical DAST analysis categories in a closed format (i.e., rating scale). In this respect, an investigative comparison of the instruments with a focus on students' conceptions has not yet been conducted. In this study, students (N = 153; 10th to 13th grade) were asked about their conceptions of scientists and their work using the DAST and the VoSAL-instrument. Some of the students (n = 99) participated in an intervention aiming to convey an authentic view of scientists and their work. Significant correlations between the results of the DAST and VoSAL-instrument were found only to a limited extent. Using the DAST, no significant differences between the pre- and post-survey could be identified, while significant trends could be identified based on the VoSAL-instrument.

Applying Rasch Model to Validate the Instrument of Student Attitudes Toward Stem (S-Stem)

Yueying Shi*, Xingyao Campus Yunnan University Secondary School, China
Xiaoming Zhai, University of Georgia, USA
Shuchen Guo*, Nanjing Normal University, China
Enshan Liu, Beijing Normal University, China

ABSTRACT

STEM education aims to enhance students' ability to apply knowledge across disciplines and cultivate their interest in pursuing related careers in the future. Attitudes towards STEM and relevant professions constitute significant outcomes of STEM. This study aims to utilize the Rasch model to validate the validity and reliability of the S-STEM survey among upper primary school students. Given the interdisciplinary of STEM, a multidimensional Rasch model was employed to comprehensively assess the internal consistency and interrelationships across various sub-dimensions. The study sample comprised 216 fifth-grade students from south China, with a final inclusion of 204 valid cases. Results indicate a high level of reliability in most sub-dimensions of the S-STEM survey. Furthermore, the multidimensional Rasch analysis revealed relatively low correlations between different dimensions. Additionally, construct maps display the distribution of students' abilities across dimensions, revealing the necessity to incorporate projects that differentiate extreme attitude expressions. The analysis of the rating scale structure indicates the consideration of modifying the 5-point scale to a 4-point scale. In summary, this study applied Rasch model to validate the S-STEM survey. The findings provide valuable guidance for further improving STEM education assessment tools, ensuring their accuracy and effectiveness in results detection of STEM education.

Strand 11: Cultural, Social, and Gender Issues

Symposium

Building Culturally Sustaining Projects and Partnerships to Support Science for the 'Rest of Us'

19-Mar-24, 8:15 AM-9:45 AM

Location: Plaza Court 4

Building Culturally Sustaining Projects and Partnerships to Support Science for the 'Rest of Us'

Gisele Ragusa, University of Southern California, USA
Colby Tofel-Grehl, Utah State University, USA
Nicole Colston, Oklahoma State University, USA
Constance Flanagan, University of Wisconsin, USA
Ken Rafanan, TERC, USA
Helen Zhang, Boston College, Lynch School of Education and Human Development, USA
Angela Kelly, Stony Brook University, USA
Beatriz Perret*, Education Development Center, USA

ABSTRACT
In a rapidly changing world with new technological and scientific development, it’s becoming increasingly important to develop scientific skills and practices to live and work. As the science education research community investigates the best practices for science learning, it is imperative to design and research learning experiences for historically minoritized groups. Our symposium contributors represent seven projects that broaden participation of science education to historically minoritized preK-12 populations in rural and urban, as well as formal and informal, contexts. These presentations leverage the affordances of technology for developing learners’ science, technology, engineering and mathematics(STEM) and computational science identity through anchoring scientific phenomena in robotics, forced migration, digital technologies, environmental science, physical computing, making and entrepreneurship, and quantum information. They will contribute an array of learning designs and research applied to different age groups, disciplines, and contexts for other science researchers to draw knowledge from and engage in discussions.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Critical Perspectives on Engineering Identities: Questioning Ideologies and Epistemologies
19-Mar-24, 8:15 AM-9:45 AM
Location: Governor's Square 14

Economic Motivations for the Pursuit of STEM Careers: Implications for Inclusion and Justice
Christopher Irwin*, Florida International University, USA
Zahra Hazari*, Florida International University, USA
Remy Dou, Florida International University, USA
Philip Sadler, Harvard University, USA
Gerhard Sonnert, Harvard University, USA

ABSTRACT
This study explores the intersection of economic motivations and STEM enjoyment in shaping students' desires to pursue STEM careers. Drawing from de Sousa Santos's epistemologies of the South, we question the degree to which a discourse of STEM jobs as good jobs is a more significant driver into STEM careers for students from minoritized populations. Using a large set of survey data from a general population of college students at 119 colleges and universities in the United States, we find that--even when controlling for their enjoyment of STEM--economic considerations drive students into STEM careers. We use a cluster analysis to show that students from minoritized populations within STEM have significantly distinct patterns of clustering based on economic motivation and STEM enjoyment. Our exploratory analysis suggests that large numbers of students with low STEM enjoyment intend to enter STEM fields, and that these students are overwhelmingly Black, Hispanic, and female. Touting economic benefits of STEM careers is likely an effective way of increasing the diversity within STEM careers, but our study highlights an important tension between inclusion and justice for minoritized communities.

A Systematic Literature Review of Survey Research on Engineering Identity

Amdad Ahmed Awsaf*, Florida International University, USA
Heidi Cian, MMSA, USA
Remy Dou, Florida International University, USA

ABSTRACT

Over the last several years, engineering identity research has gained prominence in education research circles, motivated by connections between "identity" and widely-desired outcomes such as career pursuits and selection of STEM college majors. However, quantitative research on engineering identity remains limited, with most studies focusing on qualitative research. This systematic literature review examines 85 research papers from 2007 to 2022, concentrating on survey measures related to engineering identity. Results of the review show a) a concentration of research at the postsecondary levels, with K-12 students underrepresented, and b) heavy male gender representation in survey samples. The analysis also revealed that several theoretical frameworks are frequently employed to operationalize engineering identity, but with preference for the Engineering Identity Development Scale, the Physics Identity Scale, and the Critical Engineering Agency Framework. Drawing from our analysis, we consider the consequences of both 1) existing age and gender gaps in quantitative engineering identity research and 2) preferences of particular identity frameworks within and across age and gender categories. We discuss how these possible consequences point to focal areas in engineering identity survey-based research.

An Intersectional, Longitudinal Analysis of Latiné Girls' Critical Consciousness

Summer Blanco*, University of Georgia, USA
Jessica Ortega, University of Georgia, USA
Tatiane Russo-Tait, University of Georgia, USA

ABSTRACT

Black, Latiné, and Indigenous people remain severely underrepresented in STEM. This study utilizes longitudinal interviews with 9 Latiné high school and college girls who have expressed interest in engineering careers. Using critical consciousness and intersectional frameworks, we examine their views about gender and racial inequality in engineering. Preliminary results show that experiences of privilege and marginalization, as well as socialization in neoliberal, color-evasive, and anti-Black and anti-indigenous ideologies, intersect in important ways to frame these young women's awareness (or lack thereof) of racism and sexism in STEM, as well as their sense of agency and their actions to disrupt these injustices. In this proposal we juxtapose two cases—that of Isabella and Carla— to show how their intersectional identities and lived experiences in and out of STEM spaces appear to inform different trajectories of critical consciousness or systems justification development, as lenses through which they view gender and racial inequality in STEM. These findings have important implications for researchers and educators invested in improving STEM culture, and the recruitment and retention of students of color in STEM.

Strand 11: Cultural, Social, and Gender Issues
Symposium
Working on Equity in Science Education Across Places and Spaces
19-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Court 3

Working on Equity in Science Education Across Places and Spaces
Henriette Holmegaard*, University of Copenhagen, Denmark
Lucy Avraamidou, University of Groningen, Netherlands
Cristiano Moura*, Simon Fraser University, Canada
Felicia Mensah*, Columbia University, USA
Louise Archer*, University College London, United Kingdom
Natalie King*, Georgia State University, USA
Lene Madsen, University of Copenhagen, Denmark
Christina Siry*, University of Luxembourg, Luxembourg
Betzabe Torres Olave, University of Leeds, United Kingdom
Zahra Hazari, Florida International University, USA
Laura Peña-Telfer*, Georgia State University, USA
Mi'Kayla Newell*, Georgia State University, USA

ABSTRACT
For decades discussions about educational inequities have garnered the attention of researchers, policymakers, and educators committed to social justice, who call for re-examining and rethinking approaches to science teaching and learning. However, intersecting structural inequalities still exist and researchers have documented exclusionary practices. Centered around equity, the aim of this symposium is to engage the audience with theoretical, methodological, and empirical explorations related to making science culture and practices more inclusive of diverse teachers and learners' ways of being and knowing, in particular as regards personal funds of knowledge, race, ethnicity, gender, and linguistic background.
This symposium will share empirical research with participants (i.e., school/university students, teachers) framed within contemporary theories and methodologies, and situated in diverse sociopolitical/educational contexts across the world. In doing so, it aims at addressing the following goals: (a) re-envision the fundamental principles and constructs that frame approaches to science teaching in the context of globalization and multiculturalism; (b) think critically about the use of socially-just emerging research methodologies that might contribute to more equitable science education systems and contexts; (c) re-examine the various places where science learning happens and their inclusionary/exclusionary affordances and design for learning that promotes equity and social justice.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set
Technology for Science Learning 2
19-Mar-24, 8:15 AM-9:45 AM
Location: Plaza Court 5

The Effect of Working Memory Capacity on Multimedia Learning
Do Hyong Koh*, University of Florida, USA
Muhammad Rahman, University of Florida, USA
Christine Wusylko, University of Florida, USA
Priyadharshini Prasad, University of Florida, USA
Xiaoman Wang, University of Florida, USA
Kara Dawson, University of Florida, USA
Marc Pomplun, University of Massachusetts Boston, USA
Jonathan Martin, University of Florida, USA
Albert Ritzhaupt, University of Florida, USA
Pasha Antonenko, University of Florida, USA

ABSTRACT
Our study aimed to explore the relationships between working memory capacity (WMC) and learning performance. In particular, we investigated the effect of WMC on the learning ability of undergraduate students when they study geoscience using multimedia. Our results indicated that verbal WMC was the most significant positive predictor of all measures of learning outcomes, that is, cued recall, content recognition, and transfer of learning. In addition, visuospatial WMC was only positively related to cued recall. Our study suggests that higher verbal WMC is associated with improved learning outcomes in geoscience education when students have to integrate information from text and images.

Examining Networked Participation Patterns within an Online Community Science Project
Richard Bex*, Illinois State University, USA

ABSTRACT
There has been a surge in community and citizen science projects (CCS) over the last decade; however, there is limited research on user participation patterns in online CCS projects. Understanding user patterns in online CCS can help inform the design of CCS projects and increase the chances of successfully engaging individuals with science and science learning. This paper examines users and their patterns of participation within an online paleontology CCS project community. Participants were members of the project between November 2018 and January 2020. Data included over 25,665 interactions between users and groups. Data analysis was conducted by categorizing the members of the online community using content analysis of user bios. The network was composed of 1,342 individuals across four categories: 1) public, 2) scientists, 3) education and outreach, and 4) commercial. The network was visualized using the social network analysis software. The social network analysis revealed a low-density (_ = 0.005) Tight Cluster Network. These results provide evidence for

the magnitude and diversity of public participation in paleontology. This study details methods and analytical tools for research on design and evaluation of digitally networked science education and evidence of the scale/diversity of online CCS that supports inquiry/discovery.

3D Plants: Integrating Science, Technology, and Design in STEAM+Ag Education Using Emergent Technologies

Sandra Arango-Caro*, Donald Danforth Plant Science Center, USA
Kaitlyn Ying, Donald Danforth Plant Science Center, USA
Michelle Arellano Haberberger, Saint Louis Public Schools, USA
Tiffany Langewisch, Donald Danforth Plant Science Center, USA
Nathaniel Ly, Donald Danforth Plant Science Center, USA
Kristine Callis-Duehl, Donald Danforth Plant Science Center, USA

ABSTRACT
This project addresses the disconnect between science, design, and technology and how high school students can benefit from innovative learning experiences in plant science that integrate these disciplines while gaining interest in and skills for future STEM careers. We created a research experience where students work in collaborative teams of self-identified science, technophile, and art students to create 3D models of plants under research at the Donald Danforth Plant Science Center. Through augmented and virtual reality immersive experiences, the students understand the benefits of integrating science, technology, and design. The students also practice their communication skills by disseminating their projects. We use a mixed-methods approach to assess changes in students' understanding of the role of design and technology in STEM, gain of knowledge and appreciation of plant science, and development of interests in STEM subjects and careers. Preliminary results indicate that students are more aware of the role of design in science and vice versa and are more interested in STEAM subjects. Future results will provide a better understanding of the impact on plant awareness and interest in STEAM careers. This project will contribute to the body of knowledge on theory, best practices, and practical technological applications in STEAM education.

Using Scanning Electron Microscopy for Exploring Dental Erosion in Middle-school

Bat-Shahar Dorfman*, Weizmann Institute of Science, Israel
Anat Yarden, Weizmann Institute of Science, Israel

ABSTRACT
Aspiring to enhance scientific literacy, effort has been made to give K-12 students access to current practices and technologies used in scientific research. In line with this notion, a growing number of schools have been acquiring scanning electron microscopes. This leads to science educators' need for approaches to integrating them into science instruction to benefit diverse students within heterogeneous classrooms. This study addresses the paucity of information on the benefits and the challenges of using scanning electron microscopy in the science classrooms. We examined the experiences of 70 middle-school students who participated in an activity exploring dental erosion, a global health concern. An analysis of the

students' responses to open-ended questionnaires, revealed benefits including a sense of real scientific experiences and independent learning. Technical difficulties and orientation issues emerged as the main challenges. Students gained knowledge about microscopy, the effects of materials on teeth and minimizing dental erosion. Our findings indicate that working with the scanning electron microscope may assist students to gain familiarity with modern practices and their applications and implications to everyday life. This approach demonstrates the connection between science, technology, and society and provides opportunities to engage and include a variety of learners in science learning experiences.

Is Virtual Reality an Effective Instructional Tool for Learning Anatomy and Physiology?

Carmen Carrion*, Agnes Scott College, USA
Rocio Campo-Paz, Agnes Scott College, USA
Nathan Hutcheson, Agnes Scott College, USA

ABSTRACT

Advances in virtual reality (VR) technology have opened new possibilities for teaching complex subjects such as anatomy and physiology (A&P) in STEM education. Due to the lack of studies on virtual reality in STEM higher education, this pilot study aims to investigate whether students learn Anatomy and Physiology more effectively when mastering a module through a VR experience than through traditional laboratory instruction.

A total of 70 undergraduate and graduate students at a small women liberal art's college in Atlanta, participated in this pilot study. Pre and posttest measures were distributed over four different modules: lymphatic, respiratory, digestive, and renal. Students were randomly assigned to a VR group or a non VR group during each laboratory session. Groups were statistically analyzed to see if the students in the VR group significantly learned more than the students in the non-VR group. Additionally, qualitative questions were thematically analyzed to better understand how students felt when using the VR system and the interface.

The findings suggest that once students become accustomed to the VR system and interface, the integration of VR technology to teach A&P seems to have great potential to revolutionize the educational system in STEM curricula.

Strand 13: History, Philosophy, Sociology, and Nature of Science

SC-Organized Paper Set

Socioscientific Issues and Implications

19-Mar-24, 8:15 AM-9:45 AM

Location: Plaza Court 2

Promoting College Students' Resistance to Misinformation Through SSI Instruction

Sarah Poor*, Texas A&M University, USA
Benjamin Herman*, Texas A&M University, USA
Tamara Powers, Texas A&M University, USA

ABSTRACT
Pseudoscientific belief (science misinformation and disinformation) regarding socioscientific issues (SSI) is a rapidly growing crisis that threatens our democracy, poses environmental and public health risks, and undermines educational efforts toward public scientific literacy. College students are particularly at risk for mis/disinformation considering their consistent use of technology-based media which promotes shallow and uncritical consumption of information through oversimplified and emotively charged messages. This mixed-methods investigation explored how undergraduate students' navigation of public science mis/disinformation changed through a course focused on SSI and misinformation detection. Eighty-seven undergraduate non-science majors at a large Texas university completed surveys that gathered participants' perceived credibility of three mis/disinformation media vignettes regarding 1) climate change, 2) water fluoridation, and 3) hydraulic fracturing. Students' post-intervention credibility rating of the water fluoridation and hydraulic fracturing misinformation examples was significantly lowered. The surveys also examined general mis/disinformation strategy views. Students' mis/disinformation views improved across four mis/disinformation strategies: 1) fabrication of a false controversy, 2) scientific expertise, 3) conspiracy theories, and 4) appeals to the public. This presentation will contribute to discussions regarding how college science classrooms and public science communication can be leveraged to prepare students better to critically assess information about SSI.

Beliefs in Conspiracy Theories and in the Scientific Facts About COVID-19
Anastasia Melagonitou, National and Kapodistrian University of Athens, Greece
Apostolia Galani, National and Kapodistrian University of Athens, Greece
Constantine Skordoulis, National and Kapodistrian University of Athens, Greece
Martha Georgiou, National and Kapodistrian University of Athens, Greece
Nausica Kapsala, National and Kapodistrian University of Athens, Greece
Evangelia Mavrikaki*, National and Kapodistrian University of Athens, Greece

ABSTRACT
The aim of this work is to investigate if certain people's characteristics (e.g. gender, age, education, religiosity and trust in various sources of information) affect the acceptance of general conspiracy theories and scientific data related to the COVID-19 pandemic. A 35-item questionnaire (in Greek) was distributed either to social media groups with pseudoscientific and conspiracy content or to individuals expressing similar beliefs via personal messages and we received 196 completed questionnaires. The statistical analysis of the data showed that our sample strongly accepts general conspiracy theories. Regarding COVID-19 data, it scored in the middle of the relevant scale of acceptance of pseudoscientific or scientific data, with the acceptance of conspiracy beliefs being an important predictor for the acceptance of pseudoscientific or non-scientific data about COVID-19. Age, gender and educational level do not affect belief in conspiracy theories, but religiosity and trust in information people get from their religion's representative or they find in social media do. The conclusions that emerged constitute valuable material that can be used in actions related to the formal and non-formal education of various age groups, possibly through the understanding of the Nature of Science.

The Contextualization of Socioscientific Issues in an Age of Accountability

Karrie Wikman*, University of South Florida, USA

ABSTRACT

Although the literature is replete in justifications for the implementation of the Socioscientific Issues (SSI) framework as an equitable approach for the cultivation of functional degrees of scientific literacy, actual implementation is relatively limited. Resistance results, in part, from the high-stakes nature of state and national assessments. Delivered curricula in assessed courses can consequentially be reductionist and lacking in the sociocultural aspects required for SSI reasoning. Correspondingly, this mixed methods study aimed to move a large, diverse school district toward school environments conducive to contextualized SSI learning. The following research questions guided the work: (1) What is the effect of subsuming standards-based objectives within the SSI instructional framework on science achievement? (2) How does an SSI curriculum with explicit key elements of functional scientific literacy (e.g., inclusive of moral reasoning for ethical conduct) affect the development of students' character and values as global citizens? Analysis of multilevel assessments and classroom observations revealed that students experiencing the SSI intervention showed statistically significant gains in content acquisition and that the gains were tied to implementation fidelity. Significantly large shifts in how students expressed the socioscientific orientation dimensions associated with the domain of character and values as global citizens were also found.

What are the Views of Scientists' and News' on Nature of Science in COVID-19

Xiao Huang*, Zhejiang Normal University, China
Cheng Ding, Zhejiang Normal University, China
Zhuang Zheng, Zhejiang Normal University, China
Xin Bai, Zhejiang Normal University, China
Jing Wang, Zhejiang Normal University, China
Ce Wu, China Association of Higher Education, China

ABSTRACT

COVID-19 is a pandemic, which has become a concern for scientists all over the world, especially with respect to its pathogenesis, diagnosis and treatment methods, and vaccine development. Therefore, it is appropriate to take COVID-19 as a typical socioscientific issue (SSI) for Nature of Scientific Knowledge (NOSK) explicit teaching. This study attempts to explore how NOSK can be taught within the context of SSI. In order to identify the aspects of NOSK in scientific research related to COVID-19 , we collected news from Chinese media such as People's Daily and papers from key journals. The main questions found in these texts include the identification of SARS-Co-V2, the sequencing of SARS-Co-V2 genome, the development of a diagnostic test, the clarification of its transmission mode and mutation rate. In order to identify authentic illustrations of NOSK features, we coded all relevant instances in news and newspapers, with respect to according date and theme. The results show that the key elements of NOSK emerge in the detailed research history of COVID-19.

Although most NOSK elements are implicit, we can teach about them in the context of COVID-19, a familiar SSI for the public.

Strand 14: Environmental Education and Sustainability
Related Paper Set
Educating in the Climate Crisis: Contextualizing Climate Change Understanding by Humanizing Pedagogy
19-Mar-24, 8:15 AM-9:45 AM
Location: Directors Row I

The Landscape of Elementary Climate Change Curriculum in Nations Across the Globe

Shweta Lahiri*, University of Georgia, USA
Emily Adah Miller*, University of Georgia, USA
Hong Tran, University of Georgia, USA
Ajay Sharma, University of Georgia, USA
Julie Luft, University of Georgia, USA
Joseph DeLuca, University of Georgia, USA
Elizabeth French, University of Georgia, USA

ABSTRACT
Climate change is a global challenge and school education plays a significant role in developing scientific understanding of climate change, its impacts, and ways to mitigate its effects, thereby fostering hope in young children. In our literature review, we explored the global landscape of curricular content in climate change in K-12 and focused on learning and learning contexts of this concept in elementary students. The articles were selected from peer reviewed journals that conducted studies in different countries. Following analysis of the studies, we found four major themes on climate change education: 1) majority of the research was conducted in middle and high school students while very few were carried out for elementary students 2) research focussed more on developed countries, rather than developing countries 3) curricular content focussed on causes, impacts of climate change, adaptation and mitigation strategies 4) elementary students were aware of climate change but could hold alternative conceptions about the concept. The findings showed that research on climate change education in elementary students is underrepresented. There is scope for more research about 'intentionally' designing school science curricula to introduce the concept of climate change appropriate for elementary students.

Climate Change as an Entry Point for Justice-Centered Ambitious Science Teaching

Hannah Cooke*, University of Connecticut, USA

ABSTRACT
Science teachers want to teach about climate change. The ways in which they bring this politicized topic into their classrooms matters. This study focuses on PLCs' discussions of climate change and the ways in which they incorporate it into their classes. Preliminary analysis shows that teachers use climate change as a context for learning rather than a

discipline of science. Instead of planning a unit about climate science, teachers discussed using it as a driving phenomenon to teach other disciplinary core ideas, like energy or weather. In order to support practicing science teachers, researchers need to consider the contexts in which teachers can make strides toward more effective climate education.

Enacting Multispecies Care Through Engineering Design

Veronica Cassone McGowan*, University of Washington Bothell, USA

ABSTRACT

Systems thinking can be counterintuitive to everyday ways of knowing. This can surface doubt around predicted patterns of emergence in complex systems data, especially as it relates to the current climate crisis and related justice-oriented solutions.This study describes a four-year design-based research project in which researchers engaged high school biology students in complex systems modeling to understand linkages between increasing ocean temperatures and the rate and severity of disease outbreaks in sea stars. Findings showed that students approached climate data with uncertainty and viewed their lives as separate from the impacts of climate change. Through iterative design work, youth constructed geospatial and causal-loop models of climate-related disease outbreaks that situated case studies within broader socioecological and sociotechnical contexts of historic and powered human actions. Through a critical speculative design lens, this work shows how modeling can be transformed from data visualization to storytelling and re-storying present and future worlds that center on ecological and multispecies flourishing. This work represents a new ontological dimension of modeling practices as future and worldmaking, and shows how complex systems modeling and data visualization can cultivate multispecies caring and climate action by situating climate-related phenomena in larger socioecological and sociotechnical systems.

Mapping Local Knowledge of Landscape, Nature, Climate, and History to Humanize Climate Data

Heather Killen*, University of Maryland, USA

ABSTRACT

Climate data is often big data that can suffer from increased uncertainty as it is applied to small geographic areas such as a single community. Humanizing climate data by including local knowledge of landscape, nature, climate, and history is one strategy to make big data climate sets more robust while increasing local community engagement with climate change. Here I report on an effort to humanize climate data through asset-based co-design of an online map of local knowledge. Analysis of design sessions involving six members of a rural community indicate that participants were able to both leverage and expand their knowledge of, and engagement with, their local landscape to humanize climate change within their community. Examples include sharing personal experiences of how local climate had changed in their lifetime and the ways in which local citizen organizations and city and county government offices were working toward climate change resiliency. Local mapping with community members has not been widely used in climate change education. I am

pleased to contribute understanding of how maps might support engagement and learning within the context of community-based climate change education.

Research in Artificial Intelligence-Involved Science Education (RAISE) Sponsored Session

Research in Artificial Intelligence-involved Science Education Poster Session

19-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 10

Research in Artificial Intelligence-involved Science Education Poster Session

ORGANIZERS
Xiaoming Zhai, University of Georgia, USA
Kent Crippen, University of Florida, USA

PANELISTS
Gyeong-Geon Lee Lee, University of Georgia, USA
Marcus Kubsch, Freie Universität Berlin, Germany
Christina Krist, University of Illinois at Urbana-Champaign, USA
Jamie Mikeska, ETS, USA
Geeta Verma, University of Colorado Denver, USA
Ashis Biswas, University of Colorado Denver, USA
Jennie Shin, University of Florida, USA

ABSTRACT
The advent of artificial intelligence (AI) technologies has not only revolutionized various industries but has also made a profound impact on the educational sector, especially in the realm of science education. As these technologies become more deeply woven into the fabric of educational systems, there is an urgent and unmet need to scrutinize their multifaceted roles, capabilities, ethical considerations, and potential biases. This symposium serves as a timely platform to address these critical issues, featuring a curated selection of groundbreaking research papers that delve into diverse aspects of AI's application in education. Topics range from the innovative use of large language models for automated scoring of student-written responses to the nuanced challenges of mitigating algorithmic bias in both formal and informal educational settings. The symposium also explores the transformative potential of AI in generating micro-credentials in STEM programs, providing formative feedback in simulated teaching experiences, and validating automatic assessment instruments for understanding scientific consensus. Through this intellectual gathering, we aim to catalyze a rich, multidisciplinary dialogue among educators, researchers, technologists, and policymakers. The goal is to foster a more nuanced and comprehensive understanding of how we can responsibly and effectively navigate the increasingly complex intersection of AI and education, thereby shaping a more equitable and informed future.

Awards Committee
Sponsored Session
A Celebration of NARST Award Recipients: Distinguished Contributions to Research Award [DCRA]
19-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 15

A Celebration of NARST Award Recipients: Distinguished Contributions to Research Award [DCRA]

ORGANIZERS
Amelia Gotwals, Michigan State University, USA

PANELISTS
Xiufeng Liu, University at Buffalo, USA

ABSTRACT
The DCRA recipient(s) will reflect on their work and the contributions of this work to the field and propose one or two questions that frame the future direction for global research in science education.

Indigenous Science Knowledge (ISK-RIG)
Sponsored Session
Embedding Indigenous Science Knowledge and Ways of Knowing to Promote Biocultural Diversity and Sustainability
19-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 16

Embedding Indigenous Science Knowledge and Ways of Knowing to Promote Biocultural Diversity and Sustainability

ORGANIZERS
Julie Robinson, University of North Dakota, USA
Sharon Nelson-Barber, WestEd, San Francisco, CA, USA

PANELISTS
Bhaskar Upadhyay, University of Minnesota, USA
Dana Zeidler, University of South Florida, USA
Michelle Kooman, Gustavus Adolphus College, USA
Julie Robinson, University of North Dakota, USA
David Owens, University of Montana, USA.
Jared Tenbrink, University of Michigan – Ann Arbor, USA

Pauline Chinn, University of Hawaiʻi at Mānoa, USA
Stacy Potes, University of Hawaiʻi at Mānoa, USA
David Zandvliet, Simon Fraser University, Canada
Joshua Hunter, University of North Dakota, USA

ABSTRACT
Recognizing the connection between bio- and cultural diversity is essential to fostering pathways to global sustainability. Current environmental challenges suggest a decline in humans' relationship with the natural world, and environmental injustice most significantly impacts Indigenous communities whose ways of knowing and living are inextricably connected to their place. The construct of biocultural diversity provides an appropriate framework for addressing such issues and challenges to potentially shape more positive future outcomes. One way to promote greater awareness of biocultural diversity for sustainability is through teacher professional learning and K – 12 curricula. Indigenizing STEM teaching and learning and exploring how the Next Generation Science Standards can be customized within local communities provides benefit to all learners and honors multiple epistemological orientations. Integrating Indigenous Science Knowledge and Ways of Knowing into the STEM classroom and employing culturally relevant and place-based instructional approaches can contribute to the revitalization of culture and language through meaningful connections to the natural world, which can thus increase students' sense of stewardship and relationship with their local environment. Presenters in this Administrative Session from diverse cultures, regions of the world, and science education contexts will share projects and findings that contribute to our understanding of how to meaningfully embed Indigenous Science Knowledge and local community partnerships within science education and teacher professional learning.

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set
Advancing Science Learning Through Innovative Instructional Approaches
19-Mar-24, 10:00 AM-11:30 AM
Location: Directors Row E

Advancing Equitable Science Education: Meta-synthesis on Addressing Needs of Refugee Children in the Science Classroom
Shukufe Rahman*, Indiana University, USA
Arya Karumanthra*, Indiana University, USA
Gayle Buck, Indiana University, USA

ABSTRACT
Employing meta-synthesis as a method, this study examined 34 empirical qualitative articles on meeting the needs of refugee students in K-12 science classrooms. The study aims to enable the professional community to delve deeply into a set of conceptual tools that show promise, affordances, and constraints in science education for refugee students. The findings provide empirically-based conceptual tools to engage and create science learning

environments for refugee students. These include funds of knowledge, culturally responsive pedagogy, third space, co-teaching, and multimodality science education. In considering the advancement of equitable science education, several possibilities are discussed to include and engage refugee learners in a science classroom.

Enhancing Repeating Grade 12 Students Conception of Life Science Concepts using Dialogical Argumentation

Frikkie George*, Cape Peninsula University of Technology, South Africa
Noluthando Hlazo, Cape Peninsula University of Technology, South Africa
Alvin Riffel, University of the Western Cape, South Africa

ABSTRACT

This study presents a focused investigation into improving the comprehension of Life Science concepts among Grade 12 students who are repeating their studies, within the unique context of South Africa. By integrating dialogical argumentation and assessment for learning, this study aims to address the educational challenges faced by these students. The paper is underpinned by social constructivist theoretical constructs that inform the DAAFLIM instructional model. A mixed methods quasi-experimental research design was used, and data was collected by means of a lesson observation schedule and focus group interviews. The findings show the DAAFLIM strategies enhanced the conception of the experimental group significantly compared to the control group.

A Systematic Literature Review of Scientific Uncertainty at the Pedagogical Level

Carlos Meza-Torres*, Arizona State University, USA
Ying-Chih Chen, Arizona State University, USA
Jongchan Park, Arizona State University, USA

ABSTRACT

How scientific uncertainty is conceptualized, referenced, and operationalized across the recent literature is essential for developing a framework that science educators could reference for navigating uncertainty. The purpose of this systematic literature review is to evaluate how uncertainty is described in recent educational research and what cognitive, social, and affective instructional strategies teachers are implementing to navigate uncertainty. Tentative results of this systematic literature review indicate that uncertainty is referenced as cognitive conflict, resistance, dissonance, and not-understanding. The literature also describes uncertainty in various ways such as it being experiential, able to be resolved, negotiated,can stem from various sources and as a driver for scientific inquiry. Lastly, uncertainty may be influentially associated with inconsistencies, discrepant events, quality of tasks, and problematization. Future research will build on these findings to determine how teachers implement cognitive, social, and affective pedagogical strategies for scientific uncertainty management.

Exploratory and Confirmatory Factor Analyses of an Uncertainty Management for Productive Struggle Scale

Jongchan Park*, Arizona State University, USA
Emily Starrett*, Arizona State University, USA
Carlos Meza-Torres*, Arizona State University, USA
Ying-Chih Chen*, Arizona State University, USA
Michelle Jordan*, Arizona State University, USA

ABSTRACT

Researchers have recently applied practices of uncertainty management to science learning. However, this field still lacks a well-developed conceptualization of uncertainty management as well as a suitable measurement tool for it. This study conceptualizes uncertainty management for productive struggles in science learning, develops and validates a new uncertainty management scale regarding its internal structure. Survey data collected from U.S. middle school students in 2022-2023 academic year were used for analyses to investigate validity evidence of the scale. Exploratory and confirmatory factor analyses supported a five-factor model of uncertainty management: Orientation toward uncertainty, positive and negative reactions, self-efficacy, and strategies for uncertainty management. Notably, the results suggested that positive and negative reactions to uncertainty management are related but distinct constructs. Future research can further advance the field by examining different mechanisms of each construct on productive struggles.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Symposium
Disrupting Epistemic and Ontological boundaries of doing science and producing science knowledge in K-12 classrooms
19-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 11

Disrupting Epistemic and Ontological Boundaries of Doing Science and Producing Science Knowledge in K-12 Classrooms

Sugat Dabholkar*, Rutgers University, USA
Rishi Krishnamoorthy, Penn State University, USA
Ashlyn Pierson, The Ohio State University, USA
Anastasia Sanchez, University of Washington, USA
Kathleen Arada, University of Washington, USA
Deborah Dutta, Institute of Rural Management Anand, India
Carrie Tzou, University of Washington Bothell, USA
Jordan Sherry-Wagner, University of Washington Bothell, USA
Veronica McGowan, University of Washington Bothell, USA
Alejandra Frausto Aceves, Northwestern University, USA
Ravit Duncan, Rutgers University, USA
Edna Tan, University of North Carolina – Greensboro, USA

Philip Bell, University of Washington, USA
Megan Bang, Northwestern University, USA

ABSTRACT
The social processes and milieu of how science is done, taught, and learned privileges dominant culture ontologies and epistemologies rooted in Eurocentric, white, masculine ways. In most science classrooms today students from marginalized communities are therefore expected to assimilate into these particular onto-epistemic ways of practicing science at the expense of their own identities, interests, and cultural ways of knowing. Over the past decade, science education researchers have more explicitly and forcibly advocated for desettling science education and supporting onto-epistemic heterogeneity (Bang et al., 2012). In formal K-16 settings, these efforts towards a more expansive science education often receive pushback from the educational system given the prevailing and oppressive forces under which it operates (racism, classism, sexism, ableism, and other -isms). Even in settings that wish to engage in social-change making towards more equitable pedagogies, change efforts generate tensions and challenges at different levels of scale (individuals, classrooms, buildings). In this symposium, we share across multiple and distinct projects our efforts to disrupt settled onto-epistemic ways of participating in science in K-12 classrooms, the tensions that emerge from this work, points of leverage, and directions for future work.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set
Disciplinary Literacies and Science and Engineering Practices
19-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 4

Teachers' Enactment of Disciplinary Literacy in Elementary Science Instruction
Melissa Mendenhall*, Utah State Board of Education, USA
Colby Tofel-Grehl, Utah State University, USA
Kimberly Lott, Utah State University, USA

ABSTRACT
This cross-case study explores elementary teachers’ enactment of disciplinary literacy in elementary science instruction. Participants for this research were invited to participate by responding to an online survey and were selected using a criterion sampling technique. The data source was teacher observations. Qualitative data were analyzed using immersion coding to produce basic codes, which were compared to theory-driven codes. These were categorized into global themes. The final written report includes basic codes, overall themes, global themes, and graphics displaying relationships between codes and themes for all individual cases and the cross-case narrative. Findings indicate that disciplinary literacy during science instruction, for these educators, was synonymous with content area literacy, which focuses on gaining basic literacy skills along with acquiring content knowledge through applying general literacy skills. However, each teacher’s unique conception of what

is entailed in overall effective instruction interacted with content area literacy ideas to personalize instruction. This suggests that educator preparation and in-service professional development programs should explicitly support educators to understand what disciplinary literacy is, how it is different from content area literacy, what it looks like in instructional resources, and how to implement it during science instruction.

Elementary Teacher Background and Confidence in Science Content, Crosscutting Concepts, and Science and Engineering Practices

Laura Longo*, SUNY Stony Brook, USA
Angela Kelly, SUNY Stony Brook, USA

ABSTRACT

Elementary teachers are responsible for delivering instruction across the disciplines of biology, Earth science, chemistry, physics, and engineering, and are therefore expected to demonstrate competency in all five areas while implementing NGSS-aligned pedagogical practices. This nonexperimental correlational study examined elementary science education five years after the implementation of NGSS, with a focus on elementary teachers' content knowledge, disciplinary self-efficacy, and their self-reported practices in teaching scientific phenomena, science and engineering practices, and crosscutting concepts. Elementary teachers (N=62) in grades K-5 from three school districts of varying socioeconomic status completed a survey measuring preparedness and confidence in science content knowledge and NGSS. The theoretical framework for this study is base upon Bandura's social cognitive theory as it relates to personal agency, self-efficacy, and behavioral regulation. Bivariate Spearman correlations revealed that science and engineering self-efficacy is a relevant factor in the quality and quantity of NGSS-aligned instruction, and self-efficacy in teaching engineering had the strongest correlations with the frequency of three-dimensional learning and collaboration among students. These findings suggest that requirements for elementary education should include graduate-level science coursework grounded in NGSS and geared toward elementary teachers, effective professional development for elementary teachers should focus on engineering skills and design.

Examining Elementary Preservice Teachers' Initial Abilities to Engage in Asking Investigation Questions about Three-Dimensional Scenarios

Anna Maria Arias, Kennesaw State University, USA
Soon Lee*, Kennesaw State University, USA

ABSTRACT

The integration of the crosscutting concepts (CCCs) with the disciplinary core ideas (DCIs) and science and engineering practices (SEPs) became an expectation in science classrooms within new standards documents in the U.S. However, preservice and in-service teachers have likely not had opportunities to learn in ways that integrate the CCCs, SEPs, and DCIs explicitly in their previous experiences. We investigated elementary preservice teachers' (PSTs) abilities to engage in SEP of asking question with the CCCs and DCIs prior to taking science content courses. To answer the research questions, "what are the characteristics of investigation questions written by preservice teachers before their initial science content

courses? How do these characteristics vary by scenario and use of different CCCs?," we analyzed the responses of 197 PSTs to a questionnaire that asked the students to write an investigation question using the CCCs in response to three different scenarios related to different DCIs. Through a series of chi-square tests, the findings revealed several significant associations, showing relationship between the quality of investigation questions posed by the PSTs with different scenarios and with different CCCs. The analyses have implications for instructional strategies, curriculum design, and teacher training programs to support integration of the three dimensions.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
SC-Organized Paper Set
Developing Student Interest and Science Identities
19-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 1

Social and Emotional Skills and High School Junior Students' STEM Major Selection and GPA Scores

Adam Sahin*, Harmony Public Schools, USA
Hersh Waxman, Texas A&M Unviersity, USA
Daijazi Tang, University of Houston, USA

ABSTRACT
The purpose of this study is twofold: (1) to investigate the STEM interest rates of junior students from the Class of 2024 within the STEM-focused Charter School System (CSS), comparing them to a similar group of students in the state of Texas and the nation; and (2) to examine the relationship between self-reported social and emotional skills (specifically creativity, curiosity, persistence, stress resistance, empathy, and cooperation) among junior students from the CSS Class of 2024 and their choice of STEM majors in college, as well as their GPA scores.
Descriptive, logistic regression, and structural equation model (SEM) analyses were employed to address three research questions. The findings indicate that the CSS exhibited significantly higher rates of students with STEM major plans compared to both the state of Texas and the nation across all subgroups, including females, African Americans, Hispanics, Asians, and Whites. Regarding the second research question, a logistic regression analysis revealed that being male, Asian, White, and having a parent with a college degree were advantageous conditions for students. Lastly, students with higher levels of persistence and curiosity traits displayed an increased likelihood of selecting a STEM major in college and achieving higher GPA scores.

Middle School Students' Science Career Interests Improve with School Garden and STEAM Projects Elective Course

Michelle Parslow*, Utah State University, USA
Katherine Vela*, Utah State University, USA

Rita Hagevik, University of North Carolina- Pembroke, USA
Kathy Trundle, Utah State University, USA
Laura Wheeler, Brigham Young University, USA

ABSTRACT
The need for high-wage STEM workers is increasing faster than the number of students who are majoring in STEM fields. Traditionally middle school students' positive attitudes toward science and mathematics careers decline. A school garden (added in 2021 through a university and school partnership) and STEAM learning were implemented in a middle school in the intermountain west of the U.S. to increase underutilized groups' (e.g., females and students of color) interest in STEM careers. A pre-STEAM-CIS survey was given in the fall of 2021, and a post-survey in the fall of 2022. Means and t-test statistics for the differences in interest in the individual STEAM subject careers are reported. Interest in a science career increased statistically significantly for all groups. Additionally, interest in a mathematics career remained high for all groups.

Bearing Witness During Community Science Data Talks: Small-Scale Stretches Towards Justice Oriented Teaching
Imogen Herrick*, University of Kansas, USA
Michael Lawson, Kansas State University, USA

ABSTRACT
Transforming classrooms into places where socioscientific issues are investigated through lenses of inequity, power, environmental justice, and STEM requires a pedagogical stance that teachers often struggle to cultivate. Recognizing the challenges in supporting teachers in developing this stance, this study utilizes a small-scale justice-centered routine, Community Science Data Talks, to investigate how teachers in drastically different contexts, both demographically (i.e., predominantly privileged and historically minoritized populations) and in their access to ecosystem service (e.g., shade, clean air, ect) develop after implementing a series of these conversations with their students. Using semi-structured pre- and post-interviews and planning and reflection documents, our findings indicate that both participating teachers' pedagogical narratives stretched toward more justice-oriented teaching practices. Notably, the act of bearing witness to new forms of student participation in the classroom supported teachers in deeper reflections about the purpose of STEM learning and the experiences they wanted students to have while learning. Furthermore, bearing witness brought about emotional responses from teachers in how they were able to re-see students and their forms of participation, which supported teachers in stretching toward developing more social cognitive complexity around their teaching practice and resulting learning opportunities they provide.

Cultivating science identity: An Automated Table-top Greenhouse Project with Middle School Students
Sheikh Ahmad Shah*, Boston College, USA
Daniel Raphael, Boston College, USA
Jaai Phatak, Boston College, USA

Avneet Hira, Boston College, USA
Helen Zhang, Boston College, USA
Mike Barnett, Boston College, USA

ABSTRACT
Students' perceptions of their science identity play an important role in their interest and involvement in learning science and technology. This study is part of a project in which we examined the impact on middle-school students' perceptions of their "science identity" following a project-based learning approach involving a tabletop automated greenhouse. During this project, students experienced how their coding could influence greenhouse conditions by controlling various devices (e.g., fans and lights). This allowed them to apply their scientific knowledge to solve problems through coding. Students participated in pre- and post-surveys before and after the project, and the data were statistically analyzed. Findings indicate an increase in overall "science identity" among all students after the implementation of the project. We found no difference among the students based on their gender and race/ethnicity. These results highlight the potential of our project in improving the perceptions of the science identity among students.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Addressing Bias and Equity in STEM
19-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 17

Analyzing, Critiquing, and Reimagining Diversity, Equity, and Inclusion Statements
Max Sherard*, Southern Methodist University, USA
Tatiane Russo-Tait*, University of Georgia, USA

ABSTRACT
In higher education, diversity, equity, and inclusion (DEI) statements are texts written by faculty members which explain their commitments to improving education for marginalized students. Requesting, reviewing, and acting upon DEI statements is just one practice, among others, which higher education institutions can use to transform individual and institutional practices, towards more just ends. However, DEI statements can become extensions of the curriculum vitae rather than opportunities for deeper critical reflection. In this study, we examine a large R1 university in the Southwestern US which required its faculty to submit written reflections about their contributions to diversity. We collected 22 statements from faculty in two disciplines: life sciences and quantitative sciences. Drawing on techniques from critical discourse analysis, we analyzed these statements to understand what meanings are expressed and what factors constrain or support faculty in writing more critical reflections. Results demonstrate that most faculty's statements: (a) do not clearly explicate DEI problems or causes; (b) over represent remedies to problems; and (c) locate problems within individuals rather than within systems or practices. We hypothesize that this is due (in

part) to influence of major funding sources and broader neoliberal discourses about knowing, learning, and success in higher education.

Teaching More Than Facts: A Systematic Approach for Detecting Bias in Scientific Communications

Felicity Crawford, Boston University, USA
Mae Rose Gott, Boston University, USA
Adam Labadorf*, Boston University, USA
Melisa Osborne, Boston University, USA
Thomas McKenna*, Boston University, USA
Theresa Rüger, Newcastle University, United Kingdom
Barkha Shah, Boston University, USA

ABSTRACT

Reading and evaluating scientific communications for methodological and technical accuracy is a key component of scientific training. However, training focused on the social and ethical aspects embedded within all scientific communications is seldom included in science curricula. In this study, we present student learning outcome data from four semesters of a university course on Institutional Racism in Health and Science (IRHS) where students employed the pedagogical tool Finding in Equity in LIterature and eXperimentation (FELIX). This tool, that systematizes the detection of bias and subjectivity in scientific communications, was found to be effective in improving student learning and in providing a new perspective to the work of university science students. Additionally, this approach encourages students to think about the social and ethical implications of scientific research. This is increasingly important as bias can influence the design, conduct, and interpretation of scientific research and learning how to become critical readers of scientific literature should be a key component of university teaching and learning.

Examining Equitable, Student-Centered STEM Undergraduate Instruction Across Three U.S. Institutions

Dustin Van Orman*, Western Washington University, USA
Dan Hanley*, Western Washington University, USA
Josie Melton*, Western Washington University, USA
Abbey Gray*, Western Washington University, USA
Makayla Wilson*, Western Washington University, USA

ABSTRACT

In STEM higher education, there is increasing awareness of the benefits of student- and equity-centered instruction, however, instructor uses of these practices lag awareness of impacts. In this multi-method descriptive study, we examine how STEM instructors across three higher education institutions in the U.S. understand and use student-centered and equitable instruction, and how students from 22 classrooms (N = 365) experienced learning. Our qualitative analysis uncovered practices students perceived instructors used the most, benefited their learning, and increased their belongingness to the course/field. These results reveal that common practices often do little to benefit student learning and belongingness,

and revealed several novel findings around practices students perceive to benefit them. Qualitative findings contextualize our quantitative results, which demonstrate equitable practices were those least understood and used by instructors and were least understood and experienced by students. Moreover, we found that instructors tend to underestimate the extent to which their students experience student-centered and equitable practices. We discuss how information generated from this study substantiates past research (e.g., on active learning), provides new knowledge unexplored in previous research (e.g., assessment for learning), and how this information is being used to improve equitable, student-centered teaching and learning in undergraduate STEM.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Critical Thinking to Support Teaching and Learning
19-Mar-24, 10:00 AM-11:30 AM
Location: Directors Row H

A Complex Systems Analysis of a Preservice Elementary Teacher's Physical Computing Design

Gozde McLaughlin*, Penn State University, USA
Amy Voss Farris, Penn State University, USA

ABSTRACT
Integration of computing in classrooms has led to robust forms of physical computing in science and engineering curricula (e.g., Fields et al., 2021). Entry-level programming environments and affordable computing tools increasingly make physical computing attainable in classrooms. However, a more equitable and accessible integration of physical computing presents challenges in teacher preparation. Designing and debugging microcomputing tools requires stepping into practices of circuitry and introductory computer science, which are historically unwelcoming to teachers, especially teachers outside of STEM domains and those who do not identify as makers, tinkerers, and technologists. In this study, we position physical computing design through a complex systems approach. Through this lens, building and debugging tools leveraging microcomputing aligns with established concepts in systems thinking (Yoon et al., 2018) in science education. Following a descriptive case study approach (Yin, 2017), we investigate aspects of the systems thinking that preservice teachers engage in. A complex systems approach, we found, provides an analytic framework for analyzing differences between learners' perspectives about the relationships and behaviors of their own physical computing projects in relation to our own understandings of those relationships and behaviors. Findings have implications for the interplay between physical computing and systems thinking and for teacher education.

Designing to Foster Play in Preservice Elementary Teachers' Science Learning
Amy Farris*, Penn State University, USA
Anna Kim, Penn State University, USA

ABSTRACT
Play is regarded as a productive form of making sense of the world (Goodwin, 2007; Zimmerman et al., 2019). However, for many elementary preservice teachers (PSTs), engaging in science evokes images of rigid procedures rather than a flexible and agentive conceptual innovation (Authors, 2019). We report themes arising from our pedagogical aim to foster playful scientific inquiry in an introductory physics course for undergraduates who aspire to become elementary teachers. We examine PSTs' investigations of physical phenomena related to sound and light through cycles of (re)representing the world. Our findings suggest that the use of tools and instrumentation that were familiar supported material agency and were predictive of more playful engagement with the target scientific ideas and heightened conceptual innovation. Secondly, we observed that presses for students to explain everyday phenomena through modeling promoted students' realizations of what they could not yet explain. For some, this fostered a sense of raw honesty, humor, and willingness to figure things out together. Our paper contributes to research on designing to support PSTs' understanding of scientific modeling as a form of play and conceptions of doing science as a collective means of sensemaking by iteratively acting on the world.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Subject Specific Professional Development for Science Teachers
19-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 12

Exploring a Professional Development Program Focused on Environmental Health Sciences for Middle School Teachers
Andreia Dexheimer*, Southern Illinois University Edwardsville, USA
Jennifer Zuercher, Southern Illinois University Edwardsville, USA
Carol Colaninno, Emory University, USA
Charlie Blake, Southern Illinois University Edwardsville, USA
Ben Greenfield, University of Southern Maine, USA
Candice Johnson, Southern Illinois University Edwardsville, USA
Georgia Bracey, Southern Illinois University Edwardsville, USA
Sharon slocke@siue.edu, Southern Illinois University Edwardsville, USA

ABSTRACT
We investigated the impact of an environmental health focused professional development (PD) program on teachers' understanding of and confidence in teaching environmental health topics. We conducted an exploratory study using a concurrent nested mixed methods approach to investigate teachers' perceptions of environmental health science concepts and the application of this topic within the context of their science curriculum and classroom

practices. We contextualized environmental health within the history of racially and economically diverse suburban, post-industrial, and farming communities, recognizing the link between historical environmental injustices and contemporary social justice initiatives. Our analysis revealed three primary themes from both qualitative and quantitative data: teachers (1) found the PD and curriculum on environmental health beneficial; (2) emphasized that the material and curriculum promote multiple scientific connections with students; and (3) demonstrated increased confidence in teaching the topic and using environmental monitoring tools. In this paper, we present a model for teacher PD in a novel area - environmental health education - focusing on educators in low-income post-industrialized communities, with broader applications across the United States and internationally. This paper will be of interest to NARST members working on teacher PD best practices, and interested in environmental education, informal education, and environmental health sciences.

Camp Conservation: A Teacher Professional Development Program to Promote Conservation Action

Karen Hays*, Denver Zoological Foundation, USA
Emily Peterson, Denver Zoological Foundation, USA
Luis Vasquez, Denver Zoological Foundation, USA
Angela Moss-Barber, Denver Zoological Foundation, USA
Nichole Nageotte*, Denver Zoological Foundation, USA
Shelby McDonald, Denver Zoological Foundation, USA
Rachel Dickler, Denver Zoological Foundation, USA

ABSTRACT

Teacher professional development programs around conservation education have focused largely on conservation issues and corresponding scientific content understandings. It is critical, however, to provide professional development opportunities focused on facilitating learning through a lens of conservation action to promote sustained action by both teachers and their students. In this paper, we present an overview of a new zoo-based teacher professional development program designed to develop educator skills and experience with conservation actions. The program specifically aligns to a framework for conservation education (i.e., Cultivate Caring, Amplify Intent, Remove Barriers, and Expand Impact) that addresses limitations of prior models for moving individuals from caring to action competency. We present initial results from two implementations of this professional development program with 21 teachers in the Summer of 2023. Implications are discussed regarding the value of action-based frameworks for guiding teacher professional development that empowers educators to facilitate learning through a conservation lens and promote conservation action.

Making Sense of Complex Genetics Together: A Science Teacher's Organizational Sensemaking During Co-Design.

Sara Porter*, University of North Carolina at Greensboro, USA
Hilleary Osheroff, Exploratorium, USA

ABSTRACT
In line with the conference theme, this proposal addresses an important need for science teacher learning within an age of increasing complexity in relation to our understanding and use of genetic information to describe patterns of inheritance, the risk associated with certain diseases, and patterns of ancestry. We present a representative case study of a veteran middle school science teacher learning about complex genetics in the context of a co-design curriculum process with museum scientists, a private sector scientist, and another high school science teacher. Through interaction analysis of video data, we present the sources of ambiguity the teacher grappled with throughout the co-design process and important resources for her sensemaking. Findings have implications for researchers supporting science teachers to update their curriculum to match current science knowledge through a co-design process.

White Board Speed-Dating in Physics Teacher Professional Development
Maggie Mahmood*, University of Illinois at Urbana-Champaign, USA
Devyn Shafer, University of Illinois at Urbana-Champaign, USA
Hamideh Talafian*, University of Illinois at Urbana-Champaign, USA

ABSTRACT
The shortage and isolation of high school physics teachers is a well-documented constant in the landscape of secondary science education in the United States (Mulvey & Pold, 2017; Chu & White, 2021; Rushton et al., 2017; White and Tesfaye, 2010; White & Tyler, 2014), and unless there is an unforeseen massive shift in postsecondary institutions' output of qualified physics teachers, these issues are here to stay. Physics Teaching Communities of Practice (PTCoPs) (Lave & Wenger, 1991) that bring together diversely experienced high school physics teachers from multiple schools are one effective support for out-of-field physics teachers who may be short on planning time, instructional resources, and disciplinary self-confidence. Through their interactions with other physics teachers in the community, out-of-field teachers can be exposed to new pedagogies, technical tools, and other curricular resources, ultimately helping them deliver high-quality physics instructional materials in their physics classes (Author, under review). It is in the PTCoP context that this paper examines a facilitatory strategy for engaging heterogeneous groups of teachers in comfortable and safe science content reasoning conversations: Whiteboard Speed Dating.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Teaching and Learning Focused on Emerging Technologies
19-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 6

Professional Development for Improving Precollege Teachers' Attitudes Towards Teaching Quantum Information Science and Technology
Michele Darienzo*, Stony Brook University, USA
Angela Kelly, Stony Brook University, USA

Tzu-Chieh Wei, Stony Brook University, USA
Dominik Schneble, Stony Brook University, USA

ABSTRACT
There is a growing need in the United States for a workforce that is trained in quantum information science and technology (QIST), a topic that is rarely addressed in precollege science curricula. University science education and quantum physics researchers designed and initiated a four-week, twelve-hour QIST professional development workshop for inservice high school physics, chemistry, and computer science educators. A STEM integration framework guided the workshop structure, which incorporated a situated cognition model for learning quantum concepts and computing, identifying recent advances in quantum technologies, planning curricula, and differentiating among QIST sub-fields including quantum communication, quantum computation, quantum simulation, and quantum metrology and sensing. Factor analysis identified two latent constructs in teachers' attitudes, including (1) self-efficacy in QIST pedagogy, and (2) self-efficacy in promoting student interest in QIST study and careers. Parametric comparisons of means indicated teacher participants showed significant gains in both constructs with a large effect size. This model shows promise in strengthening teachers' pedagogical content knowledge of quantum ideas so they may facilitate student engagement in quantum computing, a field that involves conceptual change and is often considered abstract, counterintuitive, inaccessible, and suitable only for the academically elite. Implications for policy and practice will be discussed.

Essential Elements of Technology Mediated Lesson Study (TMLS) Cycles: A Study with Rural Science Teachers

Clara Smith*, Brigham Young University, USA
Heather Leary, Brigham Young University, USA
Michelle Hudson, Brigham Young University, USA
Max Longhurst, Utah State University, USA
Rebecca Sansom, Brigham Young University, USA

ABSTRACT
The study aimed to identify essential elements that emerge from Technology-Mediated Lesson Study (TMLS) cycles across different collaborative science groups, examining both similarities and differences in how these groups interpret and implement the TMLS model. The research involved twelve rural science teachers, engaging in collaborative development and revision of biology lessons using three-dimensional science principles. The findings report that effective TMLS groups establish communication outside of meetings, dedicate time for personal bonding within meetings, and leverage individual strengths. Notable differences include meeting lengths, real-time work versus assignments, and rubric utilization. The study suggests that TMLS can facilitate collaboration among science teachers, especially those in remote areas, and offers insights into creating effective collaborative atmospheres.

Supporting Teacher Learning for K-12 Quantum Teaching & Learning

Nancy Holincheck*, George Mason University, USA
Tiffany Butler*, George Mason University, USA
Michele Colandene, George Mason University, USA
Jessica Rosenberg, George Mason University, USA
Ben Dreyfus, George Mason University, USA
Mia Russell, George Mason University, USA
Arion Mitchell, George Mason University, USA

ABSTRACT

Quantum science, computing, and its applications are increasingly important in modern society, yet quantum concepts are largely unaddressed in the standard K-12 curriculum. This study explores professional learning of K-12 teachers (n=49) related to quantum concepts and pedagogy. We used open-ended surveys, field notes, workshop artifacts, and interviews to examine teachers' perceptions of quantum and how they made connections between quantum and their curriculum. Our data revealed that most teachers were excited and interested in teaching quantum, but were aware of potential barriers and concerns that might get in the way of teaching quantum. We found that teachers readily identified connections to math and science in their curriculum, but only a few made connections to computing. Elementary and secondary teachers were equally likely to show enthusiasm and interest in teaching quantum.

Teachers' Engaging in Systems Thinking through Game Design: A Teacher Professional Development Program

Michael Cassidy, TERC, USA
Gillian Puttick*, TERC, USA
Debra Bernstein, TERC, USA
Santiago Gasca, TERC, USA

ABSTRACT

Understanding complex systems is a critical component of science literacy. The goal of the project is to support middle school science teachers to introduce biological systems and systems thinking into their science classrooms. The paper examines the affordances of Triadic Game Design (TGD) framework (Harteveld, 2011) for teachers' learning about systems and systems thinking in biology, and the mediating processes that potentially support that learning. Eight teachers participated in a 4-day professional development (PD) workshop where they applied systems thinking to functioning biology systems, created systems diagrams to represent the biology content they currently teach, and programmed a Scratch game. In-depth analysis a teacher pair game suggests game design can support systems thinking in two ways: (1) by requiring participants to map out a system as a basis for the game and, (2) by engaging participants in an abstraction process to represent systems components and connections using Scratch programming. Implications for PD are discussed.

Strand 10: Curriculum and Assessment
Related Paper Set
Deconstructing the Three Dimensions of Science Learning in Assessment
19-Mar-24, 10:00 AM-11:30 AM
Location: Directors Row J

Applying the Construct Mapping Approach to Three Dimensional Assessment
Mark Wilson*, UC, Berkeley, USA
Linda Morell, UC, Berkeley, USA

ABSTRACT
The National Research Council report Developing Assessments for the Next Generation Science Standards (NRC, 2014) made two recommendations regarding the design of assessments for the NGSS: first that assessment tasks should contain "multiple components" of the three dimensions, and (b) that the assessments should allow one to "accurately locate students along a sequence" of understanding and applications within each of those three dimensions. In this paper, we describe how we have followed these recommendations by (a) designing tasks that span multiple aspects of the three dimensions and include individual questions that each focus on one aspect, and (b) linking each question to a branch of a learning progression focused on the specific dimensions assigned to that task. We argue that this is a sound way to carry out the NRC recommendations, and that other designs may involve confounding of both an educational and psychometric nature. We provide background formation for this argument and provide a brief example of the type of assessment task and question that are involved. The remaining papers in the session will give in-depth exemplification of the design and its application to NGSS-inspired assessments.

Assessing Student Progress for the Crosscutting Concept of Patterns
Kristin Gunckel*, University of Arizona, USA
Malissa Hubbard, University of Arizona, USA
Sean Tan, University of California, Berkeley, USA

ABSTRACT
Patterns play an important role in science because they are the link between observations and models. Engaging in the SEPs, such as asking questions, analyzing and interpreting data, developing models, engaging in arguments, or constructing explanations, involves recognizing patterns (an important CCC). Nevertheless, little is known about how students develop proficiency in recognizing patterns useful for engaging in science or whether learning to recognize patterns is similar or different across domains (e.g., life science, Earth science). We used the BEAR Assessment System (BAS) approach to develop a construct map for the crosscutting concept of patterns and assessment questions about finding patterns in two science domains: Life science (ecosystems) and Earth science (natural resources and human impacts). We administered the items to 781 middle school students in two states. Wright maps show that student performance on the assessment items is consistent across both ecosystems and natural resources/human impacts, suggesting that learning to find

relevant patterns is similar in both disciplinary domains. A majority of middle school students in our sample performed at waypoint 2 and above, indicating they are developing or have developed the ability to connect patterns to models.

Assessing Students' Proficiency in Argumentation Across Three Scientific Domains: Physical, Life and Earth Science

Anna MacPherson*, American Museum of Natural History, USA
Mingfeng Xue, University of California, Berkeley, USA

ABSTRACT

Arguing from evidence is central to the scientific enterprise and is one of eight science and engineering practices identified in the NGSS to be taught and assessed in schools. Argumentation is a practice that spans disciplines; however, there is little research about whether and how argumentation differs across scientific domains. This paper tackles the question: How does student proficiency in arguing from evidence vary across the domains of structure of matter (physical science), ecology (life science) and natural resources (Earth science)? We used a construct modeling approach to develop tasks that included questions that assessed argumentation in physical science, life science, and Earth science and administered the items to more than 600 middle school students. Rasch modeling was used to place the items on a common scale and estimate item difficulty and student proficiency. We found preliminary evidence that argumentation items situated in life science had lower difficulty. This could be due to the order in which topics are taught in school or something unique about the nature of arguments in life science, versus physical and Earth science. This finding shows that argumentation cannot be taught as a domain-general practice; rather, students should encounter argumentation in content areas.

How Teachers Use Results From Three Dimensional Tasks to Inform Their Practice

Linda Morell*, University of California, USA
Sara Dozier*, California State University, USA

ABSTRACT

In this study, we interviewed five middle school teachers and identified ways in which they found assessment results helpful, which includes expanding their thinking about how students learn science, planning changes to their teaching practice, and communicating with colleagues. For example, teachers noticed that students sometimes performed differently on different constructs (e.g., a disciplinary core idea and a practice). Teachers also mentioned that after viewing assessment reports, they saw students as flexible thinkers. This is important because it shows teachers' thinking can be expanded away from thinking about students as "kinds of students" and towards thinking more about how a given student thinks within a given context. Teachers also commented that using assessment results that are presented through a learning progression framework enabled them to give specific feedback to students about how to move forward along a learning trajectory, and they mentioned that it is helpful to have assessment information for DCIs separate from SEPs and CCCs for collaboration purposes. This study provides results about the usefulness of the approach for the practice of teaching, especially about how teachers are able to use assessment reports to

better understand their students' thinking and use feedback to make more informed instructional decisions.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Recognition, Representation, and Responsibility: Social Justice in STEM Education
19-Mar-24, 10:00 AM-11:30 AM
Location: Governor's Square 14

A Social Justice Lens to Investigate the Institutional Nature of Recognition in Science
Matheus dos Santos Barbosa da Silva*, University of São Paulo, Brazil
Ana Kasseboehmer, University of São Paulo, Brazil

ABSTRACT
this paper sets out a social justice perspective to examine the institutional nature of recognition of high-school students as science persons. Drawing from Nancy Fraser's model of social justice, Pierre Bourdieu's ideas on social reproduction, and Carlone and Johnson's model of science identity, we investigate how recognition is collectively shaped by institutional representations and expectations about working-class and afro-Brazilian students' identification with science. This research was conducted through a one-year case study investigation in two suburban public schools in Brazil, including classroom observations, focus groups with high-school students, individual interviews, and document analysis. The findings suggest that recognition is institutionally framed and shaped by two interrelated dimensions affecting the representations and expectations about students' ability and interest to learn and engage with science: (1) schools' geographical location (center/suburbs), and (2) schools' social/racial profile. These dimensions show the socio-geographic nature of recognition in science as teachers and administration respond to their social, geographical and cultural context. We conclude by arguing how recognition as a dimension of social justice in science learning is affected by socio-spatial inequalities in the Brazilian educational system.

Complicating Identity and Representation in the Elementary STEM Classroom
Sheila Castro*, University of Florida, USA
Amy Christensen, University of Florida, USA
May Steward*, University of Florida, USA
Julie Brown*, University of Florida, USA
Ebony Terrell Shockley, University of Maryland, USA
Chonika Coleman King, University of Florida, USA

ABSTRACT
Our federally funded project aimed to equip science and mathematics teachers with culturally-responsive, affective-focused skills that support students' STEM learning, affective connections, STEM identity development, and career interests. In order to better understand students' perceptions of who does math and science, we presented students with photos of

people reflecting diverse races, ages, genders, and appearances, and sought to understand their justifications for these choices. We found that students drew on personal connections to make determinations, associated high-status symbols with STEM jobs, maintained gendered perceptions of STEM participation, and demonstrated how certain characteristics mediated their justifications regarding STEM engagement. Understanding how students conceptualize doers of STEM can help build more robust interventions to help students counter problematic narratives and promote inclusion.

Understanding to Unlearn: Implications of Unconscious Bias in STEM Teaching and Learning

Uchenna Emenaha Miles*, University of Texas at San Antonio, USA
Ian Thacker, University of Texas at San Antonio, USA
Samantha Leihsing, University of Texas at San Antonio, USA

ABSTRACT

The purpose of this study was to examine how pre-service teachers might make sense of curriculum targeting the topic of racial bias. We designed and implemented a three-day curriculum intended to engage 36 undergraduate preservice STEM teachers in learning the major the concepts and consequences of implicit racial bias and assess students' understanding of this curriculum as well as their expected teaching practices. A qualitative analysis of students' written artifacts and assignment yielded that students learned that racial bias learned and can negatively impact teacher perceptions and student outcomes. Preservice teachers also shared that they were committed to make use of teaching strategies and felt confident in their abilities to identify strategies to mitigate implicit racial bias in their practice.

Views About Social Justice in Science Education Among Academic Staff Responsible for Initial Teacher Education

Michael Reiss*, UCL, United Kingdom
Wilton Lodge, UCL, United Kingdom
Marian Mulcahy, UCL, United Kingdom

ABSTRACT

In this project our research question is 'What do university secondary science ITE (Initial Teacher Education) academic staff in England understand by social justice and what they believe should be the role, if any, of school science in contributing to it?'. We undertook individual, semi-structured interviews with twelve university academic staff (known as 'tutors') with secondary science ITE cohorts within England. Interviews were transcribed and analysed using deductive and inductive thematic analysis. Six main themes were identified: 'Social justice in science education', 'Representation and inclusion', 'Inequities', 'Curriculum opportunities', 'Pedagogies', and 'Assessment'. There was near universal support for the inclusion of issues to do with social justice in science education. Precisely what was meant by social justice varied between interviewees though there were considerable commonalities. There was virtually universal agreement that school science tended to be too Western and male. There was a widespread view that good science teaching could address issues to do

with inequity, with a number of interviewees identifying opportunities in the science curriculum for showing how science has sometimes failed to advance social justice. There were many instances identified where the way in which a teacher taught could be used to advance social justice.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Transnational Lenses: Refusing Deficit Portrayals and Recognizing Diasporic Identities
19-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 3

Challenges and Opportunities to Navigate Identities in STEM: A Case for a Black Immigrant TA

Sule Aksoy*, CUNY Graduate Center, USA

ABSTRACT
Using identity and intersectionality as an analytical framework, this study explores the challenges and opportunities that a Black Immigrant teaching assistant navigates at a private research-focused university in the Northeast United States. Given the tension in shaping teacher and science identity within STEM departments, it focuses on the experiences of an international graduate teaching assistant (GTA) in chemistry. This qualitative single case study highlights how multiple identities influence one's identity formation with a focus on recognition and professional development. The findings show linguistic resources, the sociopolitical context of STEM departments, and ethnic and gender identities play a role in one's recognition as a science person and a teacher. A detailed description of the research will be provided, and the rationale behind the design will be discussed.

(Re)conceptualizing Culturally Responsive STEM in US Schools: Including Voices of Black Immigrant Students

Chonika Coleman-King, University of Florida, USA
Takeshia Pierre*, University of Florida, USA
Kenesma John, University of Florida, USA
Mercedes Machado, University of Florida, USA
Taryrn Brown, University of Florida, USA
Hyunyi Jung, University of Florida, USA
Koree Badio, University of Florida, USA

ABSTRACT
Despite efforts to improve diversity in STEM careers in recent decades, Black people continue to be underrepresented in STEM fields. Disparities in STEM careers start long before young adulthood, as Black students lack equitable access to high-quality STEM instruction (among other barriers) in K-12 schools. Despite the efforts of some researchers to center the Black

experience in STEM, Black people are often treated as a homogenous group and thus, Black immigrants are routinely left out of discussions on Black education. Consequently, little research exists to examine Black immigrants' educational experiences. We use the case study of two students–Talea, a 1.5-generation Jamaican immigrant, and Marcus, a second-generation Jamaican immigrant–to explore how their identities as Afro-Caribbean immigrants uniquely shaped their perspectives on STEM teaching and learning and as a result, how these ideas might help us (re-)conceptualize possibilities for culturally centered STEM in US schools. We examine 1) How Afro-Caribbean immigrant youth's transnational notions of race and identity shape their perspectives on teaching and learning in US schools, and 2) How home and community learning experiences shape Afro-Caribbean immigrant students' views on possibilities for STEM learning in schools.

The Role of Culture and Socialization on South Asian Women's Pursuit of STEM Education
Kinza Shaukat*, University of Western Ontario, Canada
Anton Puvirajah, University of Western Ontario, Canada

ABSTRACT
This study examines the experiences of five South Asian women who aspire for careers in Science, Technology, Engineering, and Mathematics (STEM) at a university in Ontario, Canada. It also analyzes the ways in which cultural and societal experiences shape their pursuit of a STEM degree. Using intersectional feminism and diasporic identities as lenses this study examines through narrative research, five female South Asian undergraduate students' personal experiences and perspectives on societal and cultural factors shaping their pursuit of a STEM degree. Data was collected through semi-structured interviews. The findings are presented through qualitative narrative storytelling. The findings discussed the extent to which the participants' identities were constructed through the home and school life, as well as ideas of educational significance in their cultures.

Strand 12: Technology for Teaching, Learning, and Research
Related Paper Set
Leveraging Embodied Cognition Using Virtual Reality in Middle School Science Education
19-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 5

Co-Designing a Science Lesson with VR in Middle School Science
Eduardo Estrada-Rosado*, Wake County Public School System, USA
Tyler Harper-Gampp, North Carolina State University, USA
Cesar Delgado, North Carolina State University, USA
Ruth Mathenge, North Carolina State University, USA
Matthew Peterson, North Carolina State University, USA
Karen Chen, North Carolina State University, USA
Linfeng Wu, North Carolina State University, USA

ABSTRACT
A majority of studies implementing VR have occurred at the post-secondary level with limited investigations in K-12 spaces. Therefore, we describe our process of co-designing a lesson on energy production with middle school science teachers that incorporated our virtual environment, [name blinded]. Using a 5E lesson plan template as a guide, the teachers and the project team co-designed a four day unit where students worked in groups researching an assigned energy production type, exploring scale in context, and analyzing misconceptions. Their final product was a shared digital slideshow that included a powers of ten scale. Follow up interviews with the collaborating teachers identified opportunities for VR within existing curriculum, highlighted the salience of situating VR within educational standards, and provided rich future recommendations for VR implementation. Therefore, our process of co-designing a lesson incorporating [name blinded] within a practical middle school classroom setting serves as a guide for future VR implementation and educational research.

Impact of VR Science Lesson on Students' Knowledge of Scale

Cesar Delgado*, North Carolina State University, USA
Tyler Harper-Gampp, North Carolina State University, USA
Ruth Mathenge, North Carolina State University, USA
Matthew Peterson, North Carolina State University, USA
Karen Chen, North Carolina State University, USA

ABSTRACT
"Scale, proportion, and quantity" is a crosscutting concept that supports connections across scientific disciplines, but research shows that learners' have difficulty with these concepts. The impact of a VR lesson on student knowledge of size and scale was assessed using a modified version of the ASSC with a pre- post-test design and some Likert-scale items on perceptions of learning. Students went from aggregately ranking ant smaller than seven microscopic entities (similar to elementary students in prior studies), to ranking it larger (similar to high school students). Ordering by size, grouping by size, and accuracy of absolute size estimation improved with effect sizes near 0.3 but did not reach statistical significance. 54% of students indicated they learned something about size and scale. This study shows that a VR lesson can positively impact students' knowledge of the size and scale of scientific entities that are important in the NGSS. The theoretical framework of embodied cognition provides an explanation for the power of direct experience with these entities through virtual reality.

Student Impressions about a VR Science Lesson

Tyler Harper-Gampp*, North Carolina State University, USA
Cesar Delgado, North Carolina State University, USA
Matthew Peterson, North Carolina State University, USA
Karen Chen, North Carolina State University, USA
Ruth Mathenge, North Carolina State University, USA
Rebecca Planchart, North Carolina State University, USA
Robert Kulasingam, North Carolina State University, USA

ABSTRACT

Virtual reality (VR) has begun to pervade the consumer market resulting in an increase in educational applications. However, research on students' affective outcomes using VR within educational settings is still emerging. Following a VR science lesson at a local middle school, participating students completed a 12-item survey to gauge their impressions. The items were related to: enjoyment; learning with VR; learning scale within VR; changes in scale reasoning with VR; interest in STEM careers; and applications of VR. We focus on students' affective outcomes; however, we analyzed the responses to all questions. Results indicated that a majority of students enjoyed the experience, and indicated that there was nothing they did not like. A thematic analysis of student followup interviews revealed particular features that elicited enjoyment, barriers to implementation, and approaches to improve student affective outcomes for future implementation. Therefore, this study demonstrates that embodied interactions within VR are engaging for middle school students, providing students with the opportunity to experience NGSS-referenced entities first hand. Barriers identified by students for implementation of VR in formal educational spaces including visually induced motion sickness, blurry visuals, and headaches. Possible strategies for improved experiences are identified.

Impact of a VR Science Lesson on Reform-Oriented Nature of Science Instruction

Ruth Mathenge*, North Carolina State University, USA
Robert Kulasingam, North Carolina State University, USA
Cesar Delgado, North Carolina State University, USA
Matthew Peterson, North Carolina State University, USA
Karen Chen, North Carolina State University, USA

ABSTRACT

Over the last two decades, there have been calls for reformed teaching in mathematics and science education. A comprehensive review of empirical research has established that student-centered active learning aligned with the reform vision improves students' cognitive outcomes. The literature, however, indicates a gap in the effects of immersive virtual reality (VR) on STEM teaching and learning, specifically on whether and how it may support reform-oriented teaching. The present study was a within-groups quasi-experimental research design. The research team and the collaborating teachers co-designed a lesson based on constructivist learning theory. Two classes were observed utilizing the Reformed Teaching Observation Protocol over two instructional days, with the first day not incorporating VR and the second day incorporating VR. Classes A and B received a total score of 59 and 61 for the first instructional day and 80 and 81 for the instructional day integrating iVR, respectively. The scores in all five RTOP categories increased, with the most significant increases recorded in propositional knowledge and communicative interactions. The findings indicated that using a VR learning environment informed by constructivist learning theory promoted the reformed nature of teaching and learning. It bolstered students' engagement, particularly in student-student conversations.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set
Information Engagement
19-Mar-24, 10:00 AM-11:30 AM
Location: Plaza Court 2

The Inevitably Social Nature of Public Engagement With Science: Epistemic Networks and Science Education

Ayelet Baram-Tsabari, Technion - Israel Institute of Technology, Israel
Noah Weeth Feinstein*, University of Wisconsin-Madison, USA

ABSTRACT
In this theoretical paper, we focus on a feature underemphasized by education researchers: public engagement with science is a social process involving one's epistemic networks. In this context, an epistemic network is a set of people who support sensemaking by providing new information and aiding in the interpretation and reconstruction of scientific knowledge in context. Understanding when epistemic networks are useful–as well as how and for what ends education built around them might be effective–requires a clearer sense of their involvement in different forms of public engagement with science. We draw on research from education, communication, and science and technology studies to develop the idea of an epistemic network. The core of our argument is that science education in our epistemically challenging landscape should help people become better at creating, adjusting, and using their epistemic networks to make personal and civic decisions and to understand the natural world. We contrast the inevitably social nature of all public engagement with science with the particularly social– interpersonal – nature of some engagement with science for collective and individual decision-making. We conclude with ways in which science education may respond to the role of epistemic networks in public engagement with science.

"Placebo works wonders." – Chinese and German Biology Students' Beliefs about Alternative Medicine and Evidence-based Medicine

Elvira Schmidt*, Justus-Liebig-University, Germany
Jing Jin, Stockholm University, Sweden
Shu-Nu Chang-Rundgren, Stockholm University, Sweden
Kerstin Kremer, Justus-Liebig-University, Germany

ABSTRACT
Health-related discussions in society and media - specifically during the Covid-19 pandemic – showed that individuals are confronted with Alternative Medicine (AM) and Evidence-based Medicine (EBM) and thus with scientific and pseudoscientific perspectives. When it comes to reflective decision-making about AM and EBM, knowledge but also beliefs are important. Previous research with biology students showed that AM is common although they have little knowledge about it. To date, systematic studies on beliefs about AM and EBM of biology students are missing. Based on the Theory of Planned Behavior, the present study elicited

German (N=40) and Chinese (N=28) biology students´ beliefs about AM and EBM via an open-ended questionnaire. The behavioral, normative and control beliefs were evaluated using qualitative content analysis. The results showed that both samples mention efficacy, scientificness, and safety of treatments as important belief categories. For AM, behavioral beliefs include the placebo effect, scientific evidence of efficacy, and natural and mild effects. These beliefs indicate that biology students do not have a clear understanding of EBM and AM, which can influence their decision-making. Based on these findings, a large-scale quantitative comparative study is planned to investigate these and other correlations.

"We're Putting All Our Trust Into What He's Saying": Students' Evaluations of Science (Dis)Information

Daniel Pimentel*, University of Alabama, USA

ABSTRACT

A central focus of science education is teaching students to create and evaluate arguments based on evidence and reasoning. However, it can be challenging to evaluate scientific claims on the internet. This study reports a set of think-aloud interviews designed to understand the strategies that students used to evaluate science (dis)information online. Nine students participated in two evaluation tasks. Only two students were able to correctly identify that a website contained misleading claims. Those two students focused on evaluating the credibility of the people behind the information rather than the evidence and reasoning provided on the website in question. These results suggest that teaching students to evaluate source credibility might support identification of science disinformation online.

Educating Future STEM Professionals through Misinformation/Disinformation Responsive Instruction

Benjamin Herman*, Texas A&M University, USA
Sarah Poor, Texas A&M University, USA
Aaron Kidd, Texas A&M University, USA
Daniel De Jesús, Texas A&M University, USA
Davis Varghese, Texas A&M University, USA
Michael Clough, Texas A&M University, USA
Asha Rao, Texas A&M University, USA

ABSTRACT

The extent people place trust in the legitimate scientific community versus purveyors of misinformation/disinformation has widespread and potentially disastrous impacts on human and environmental well-being. This was evident in how people consumed, spread, and acted upon information regarding the COVID-19 pandemic and vaccination. The mixed-methods study reported here investigated how pandemic responsive instruction on the nature of COVID-19 science (NOCS), vaccine development, misinformation/disinformation, and other factors (e.g., political orientation) associated with 506 post-secondary science major biology students' developing COVID-19 science views and vaccine acceptance. After instruction on COVID-19 science and the biology and practices associated with vaccine development, the students' forced-choice elicited and qualitatively expressed NOCS views and COVID-19

vaccine conspiracy resistance and acceptance/support significantly improved from a small to large extent. Furthermore, changes in students' COVID-19 vaccine acceptance from before to after COVID-19 science and vaccine instruction significantly associated with sociocultural grouping (e.g., race/ethnicity and political orientation) and changes in NOCS views and conspiracy resistance. This study's findings demonstrate the importance of recognizing sociocultural diversity among students while also effectively implementing NOS instruction in large lecture post-secondary science majors' courses – particularly when addressing the science related to on-going SSI.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set
Science as Civic Learning in K-12 System
19-Mar-24, 10:00 AM-11:30 AM
Location: Directors Row I

Youth Civic Engagement for the Environment and Sustainability
Ailee Odom, University of Florida, USA
Megan Ennes*, University of Florida, USA
Martha Monroe, University of Florida, USA

ABSTRACT
Civic engagement for the environment is one strategy for approaching environmental and sustainability education. Solutions to large-scale environmental issues cannot rely on individual actions but rather require collective and civic action to impact communities as a whole. This study examined the impacts of a civic engagement curriculum that led youth in identifying an environmental issue in their community, its root causes, potential decision makers who could make a change, and how to make a persuasive ask. Seven 4H groups participated in the pilot and 37 youth completed a pre/post survey assessing their levels of self-efficacy, positive youth development (PYD, the belief that they can make decisions that positively impact their life), and project-based skills. Results suggested that the youth saw an increase in their levels of self-efficacy and PYD. However, the differences in their project-based skills and civic action competencies was influenced by the type of project they completed. The post-survey scores indicated that the groups that scored the highest on the post-assessment completed projects that focused on youth being directly involved with community members and public officials. This paper will discuss the creation of the curriculum and implications for future research.

Exploring the Intersection of Civic and Science Outcomes: The Heat Island Task
Dante Cisterna*, ETS, USA
Karen Quintero, ETS, USA

ABSTRACT
Conceptualizing and assessing K-12 students' application of science topics with civic implications are critical to support disciplinary integration. Given the concerns about the

impact of global climate change (GCC) on local and global communities, science and civic learning in K-12 schools can increase students' awareness and concerns about GCC (e.g., Kessler, 2021). Drawing on the intersection between civic and science learning goals, we designed a performance task focused on the exploration of 'heat islands,' a local phenomenon affecting cities, and exacerbated by GCC. We describe how this task addresses science and civic learning goals, as students engage with different activities to inform their local community about the impact of heat islands. We report the results of a cognitive interview study and one classroom study with middle and high school students to identify science and civic outcomes of the task. Participants leveraged their understanding of heat islands to include evidence, identified concerns about others affected by the heat island effect, and identified civic implications for the welfare of their communities. We highlight implications for using performance tasks that involve the intersection of disciplinary science and civics.

Environmental Education in the Classroom: Selected Early-Career Teachers' Experiences Navigating Pre-service and In-service Activity Systems
Sarah Nuss*, William & Mary, USA

ABSTRACT
Increasing anthropogenic (human-caused) impacts on the planet are responsible for global environmental issues such as rising global temperatures, severe drought, and sea-level rise that are growing at rapid rates (Steffen et al., 2011). These impacts suggest a vital need for an environmentally literate society. One pathway to promoting this goal of environmental literacy is through environmental education, a process which helps people develop understanding and skills to address both local and global environmental issues (NAAEE, n.d.-a). If environmental education is required in K-12 education, teachers would play a significant role in ensuring how it will occur.
Few studies have explored how an introduction to environmental education within pre-service teacher preparation influences teacher use of environmental education once novice teachers are in their own classrooms. Additionally, little is known about how the differing activity systems of teacher preparation and in-service teaching influence teachers' integration of environmental education into the K-12 classroom. In this study, I explored the lived experiences of early career teachers, the associated perspectives from school administration and university faculty, and the meaning-making they have constructed during their participation within and between the activity systems of their teacher preparation programs and their K-12 schools.

Lunch Break - See the City!
19-Mar-24, 11:30 AM-2:30 PM
Location: Off Site

Awards Committee

Sponsored Session
A Celebration of Early Career Research Award [ECRA], Outstanding Dissertation Research Award [ODRA], and NARST Fellows
19-Mar-24, 2:30 PM-4:00 PM
Location: Governor's Square 15

A Celebration of Early Career Research Award [ECRA], Outstanding Dissertation Research Award [ODRA], and NARST Fellows

ORGANIZERS
Amelia Gotwals, Michigan State University, USA

PANELISTS
Lama Jaber, Florida State University, USA
Julia Plummer, Penn State University, USA
Douglas Larkin, Montclair State University, USA

ABSTRACT
The ECRA, ODRA, and Fellows' recipients will reflect on their work and the contributions of this work to the field and propose one or two questions that frame the future direction for global research in science education.

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set
Complex Systems and Socio Scientific Issues
19-Mar-24, 2:30 PM-4:00 PM
Location: Directors Row E

Exploring Quantitative Reasoning Through Computational Modeling of a Socio-Scientific Issue

Laura Zangori*, University of Missouri, USA
Zhen Xu*, University of North Carolina, USA
Troy Sadler*, University of North Carolina, USA
Swarna Mahapatra*, University of Missouri, USA

ABSTRACT
Although extensive research has focused on utilizing mechanistic models and system models to develop an understanding of socio-scientific issues (SSI), research in how K-12 students engage in model-based reasoning about scientific phenomena using computational modeling is just emerging. This study draws upon the framework of quantitative reasoning (QR) cognitive structures to explore how middle school students perceive and apply QR to computational models for reasoning about viral spread. The students participated in a three-day lesson during which they employed the computational

model Disease Spread to investigate the relationship between probability and disease spread. Data collection included student worksheets, interviews, audio recordings, and field notes. Data analysis revealed all three of the QR phases: quantitative act (QA), quantitative interpretation (QI), and quantitative modeling (QM). Results underscore the interaction between QI and QM in shaping students' perceptions of computational models as either factual teaching tools or as epistemic reasoning tools. Additionally, the findings suggest that prompting specific measurement usage in computational models is crucial for assessing student understanding of phenomena and quantitative reasoning. These findings have implications for researchers, educators, and curriculum developers aiming to enhance students' engagement with computational models in SSI-based learning.

Identifying Building Blocks and Misconceptions: Exploring Undergraduates' Perceptions of Decentralization and Stochasticity in Complex Systems

Lin Xiang*, University of Kentucky, USA
Hunter Chandler*, Bluegrass Community & Technical College, USA

ABSTRACT

Based on existing literature that identifies decentralization and stochasticity as the most challenging concepts for students when learning about complex systems (CSs), this study conducted interviews with undergraduates who had previously completed a survey on their perspectives of CSs to reveal their underlying conceptions of CSs and their perceptions of decentralization and stochasticity. The findings revealed that none of the undergraduates explicitly used decentralization or stochasticity as a criterion when considering a CS. Instead, many emphasized the significant number of interconnected components and interactions within CSs. The undergraduates implemented a variety of underlying ideas to comprehend decentralization and stochasticity in CSs, which encompass both the building block ideas that enable them to develop a deeper understanding of decentralization and stochasticity and the misconceptions teachers need to address during instruction. During the interviews, the undergraduates mentioned three types of systems: 1) human societies and organizations, 2) natural systems, and 3) mechanical systems, but they predominantly referred to human societal systems when explaining their responses. Meanwhile, the undergraduates' perceptions seemed to be associated with the specific complex systems they utilized while responding to the interview questions.

Exploring System Dynamics of Complex Societal Issues Through Socio-Scientific Models

Li Ke*, University of Nevada, Reno, USA
Eric Kirk, University of North Carolina at Chapel Hill, USA
Rebecca Lesnefsky, University of North Carolina at Chapel Hill, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA

ABSTRACT

In this paper, we explore how modeling can facilitate students' systems thinking about complex societal issues. Building on evidence from prior research in promoting systems thinking skill through modeling in scientific contexts, we hypothesize that a similar modeling approach could effectively foster students' systematic understanding of complex societal issues. In our previous work, we introduced socio-scientific models that incorporates social factors and address the learning needs of students making sense of SSI. In this study, we investigate the challenges and opportunities learners encounter while engaging in socio-scientific modeling activities. We conclude paper with implications for science teacher and learning and future research directions.

Exploring Students' Certainty of Assumptions About Socioscientific Issues

Jenny Dauer*, University of Nebraska-Lincoln, USA
Asghar Gill*, University of Nebraska-Lincoln, USA
Caitlin Kirby, Michigan State University, USA
Amanda Sorensen, Michigan State University, USA

ABSTRACT

Many students are often familiar with SSI contexts and have already formed opinions that arise from their experiences. This can be an advantage, allowing students to draw on existing resources and knowledge in their reasoning, but also may be problematic in terms of open-minded evidence evaluation. Informed by social constructivism and self-regulated learning, we explored 1) Do student characteristics (stakeholder identity, personal epistemology, emotions, actively open-minded thinking, or metacognition) predict their assumption certainty about an SSI? 2) How do students describe the basis of their assumptions? 3) Is there a relationship between students' certainty of assumptions and performance on a coursework task that requires them to use evidence to argue about an SSI solution? We found that stakeholder identity strength predicted students' certainty of assumptions. Few students could clearly cite a reason for their assumptions. However, only metacognitive awareness predicted students' ability to use evidence in their coursework, and stakeholder identity did not. This study seeks to better understand how student identities and motivations intersect with desired outcomes of science education such as socioscientific reasoning. In particular, understanding how student identity influences classroom experience will inform best practices during instruction using controversial issues.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
Discourse and Argumentation
19-Mar-24, 2:30 PM-4:00 PM
Location: Governor's Square 11

Students' Interest in Science: Influence of Students' Brain Type

Julia Welberg*, University of Münster, Germany
Daniel Laumann, University of Münster, Germany
Susanne Heinicke, University of Münster, Germany

ABSTRACT

Learners' engagement and performance are influenced by their interest, so there is a particular need for a deeper understanding of their interest in science subjects. While prior

research focused on sex-specific distinctions, recent studies indicate that it may be important to explore sex-independent factors influencing interest in science. This study adopts the Empathizing-Systemizing Theory (EST) to analyse students' interest in science subjects, offering a diverse perspective beyond sex. EST comprises two dimensions: empathizing and systemizing thinking. Depending on their relative parameter value, groups can be formed analogous to sex ("brain types"). The study investigates how secondary school students' interest in different science subjects varies based on sex and brain type. Additionally, it examines their responses to more empathizing- or systemizing-framed contexts. Surveying N = 2915 students from German secondary schools, results, amongst others, reveal that sex-based disparities are absent in biology but emerge in chemistry and physics. However, brain type and systemizing thinking, shows a significant higher explained variance compared to sex about science interest connections, especially in physics. The results also indicate a correlation of brain type and the interest on contexts for physics lessons with respect to the contexts' formulation, which holds relevance for designing effective physics lessons.

Exploring Speech and Listening Characteristics of Elementary Teachers in Generative Science Classrooms

Ercin Sahin, University of Iowa, USA
Zeynep Mentesoglu*, University of Iowa, USA
Jee Suh, University of Alabama, USA
Brian Hand, University of Iowa, USA
Gavin Fulmer, University of Iowa, USA

ABSTRACT

Recent science standards encourage a shift from transmissive instruction to more generative instruction which highlights the active participation of learners. To achieve this objective, immersive approaches play a crucial role in promoting learners' active participation in constructing and evaluating ideas. In this study, we examined the characteristics of teacher speech and listening in an immersive knowledge generation approach which emphasizes the use of three epistemic tools: language, dialogue, and argument. Data for this study were acquired through classroom observations of nine K-5 teachers and by gathering scores from the epistemic orientation survey. A codebook was designed based on the literature to assess teachers' speech and listening characteristics regarding three epistemic tools. The findings suggest that teachers who obtained higher (lower) scores in the epistemic orientation survey also demonstrated proficient (limited) performance in terms of informal speech and attentive listening within their generative science classrooms The analysis of classroom videotapes yielded evidence regarding the ways in which employing informal speech and promoting equity of intelligence can improve students' engagement and active participation within the classroom. This paper should be of interest to science educators engaged in continuing professional development of teachers, pedagogical knowledge, and instructional strategies.

Grade 8 Students' Argumentation about Scientific vs Socio-Scientific Issues

Ihsan Ghazal*, Texas Christian University, USA

Saouma Boujaoude, American University of Beirut, Lebanon
Hayat Hokayem, Texas Christian University, USA

ABSTRACT
This study explores students' reasoning in scientific and socio-scientific contexts, considering emotional responses and cultural influences. Conducted in a Grade 8 biology class over 12 weeks, the research engaged 24 students in argumentation activities. Responses were categorized as scientific, emotional, or a blend of both. Two types of scientific reasoning emerged: macroscopic (observable phenomena) and microscopic (described micro-mechanisms). Results indicated varied reasoning across activities tied to activity nature and prior conceptions. Cultural and social contexts often resulted in emotional reasoning, deviating from scientific rationale. Scientific activities showcased mainly microscopic scientific reasoning. Transitioning to socio-scientific contexts, activities about AIDS and allergies revealed mixed reasoning patterns. In the culturally embedded mankushe activity (about cultural food), most students employed macroscopic scientific reasoning, except for one who applied microscopic reasoning. However, connecting allergic reactions to body mechanisms proved challenging. The study's insights contribute to science education, informing teaching strategies, curriculum design, and cross-cultural science education.

Evidence of Global Thinking in Students' Socioscientific Issues Discourse
Mary Short*, The George Washington University, USA

ABSTRACT
The instantaneous movement of information and imagery in the current era has fundamentally altered our constructions of reality as the outer world of media becomes a central aspect of the "inner world of society" (Beck, 1999, p.1). This recent shift requires us to rethink what types of knowledge we anticipate students will bring to classrooms and figure out new ways to leverage them for student sensemaking about socioscientific issues (Odden & Russ, 2019). This paper presents a conceptual framework that addresses this need. The paper then operationalized the conceptual framework by presenting qualitative findings from an interactive analysis framework designed to identify evidence of students' global thinking in discourse about socioscientific issues.

Evolving Argumentation Goals And Shifting Discourse Moves: Tracing The Work Of One Middle School Student
Harini Krishnan*, University of Utah, USA
Lama Jaber, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT
Argumentation is a means of engaging students in the epistemic practices of science–generating claims that are supported by evidence, evaluating claims, and challenging alternative claims. However, students' sensemaking during scientific argumentation is influenced by the manner in which students use discourse moves to interact with their peers. This investigation examines the shifts in the discourse moves of one middle school student

(Sandi) with the evolving local task goals of a small group during a scientific argumentation activity and how these shifts shaped opportunities for sensemaking in the small group. Our findings demonstrate that similarly phrased discourse moves can variably affect students' sensemaking, depending on how they are delivered by the students. The findings from our investigation demonstrate that arming students with the tools of argumentation, such as question stems, alone is not sufficient to ensure productive epistemic work.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
SC-Organized Paper Set
Inclusive Teaching Practices
19-Mar-24, 2:30 PM-4:00 PM
Location: Directors Row I

Strategies to Support Multilingual Learners Engaging in Science Practices
Collins Moga*, University of Massachusetts Dartmouth, USA
Stephen Witzig, University of Massachusetts Dartmouth, USA

ABSTRACT
The purpose of this study is to explore the strategies a veteran high school science teacher uses to support multilingual learners(MLs) engaging in science practices. We used qualitative case study methodology to gain insight into the participants' subjective experiences and perspectives. We posit three assertions based on the data: (1) It is important to use strategies that encourage MLs to engage within classrooms; (2) A key teacher role is to make science less abstract, and (3) Culturally responsive teaching practices facilitate MLs engagement in science. This paper should be of interest to NARST members engaged in science teacher education and training to uncover best practices to engage students in science practice and to facilitate the equipping of skills that foster effective teaching among culturally and linguistically diverse student groups.

Using Culturally and Linguistically Responsive Teaching to Promote Students' Engagement in Science and Engineering Practices
Hada Herring*, University of Florida, USA
Amber Deig, University of Florida, USA
Julie Brown*, University of Florida, USA
Mark Pacheco, University of Florida, USA

ABSTRACT
This work presents findings from a study of culturally and linguistically responsive teaching (CLRT) with learners in two secondary biology classrooms. Specifically, it explored how CLRT shaped student participation in the Next Generation Science Standards' science and engineering practices (SEPs). Teachers received yearlong CLRT training, and video/audio recorded observational data from twelve lessons were collected from these two classrooms as part of a larger federally-funded project. Findings indicate that elements of CLRT

promoted student participation in SEPs, mainly Practices 1 (asking questions/defining problems), 2 (developing and using models), 3 (planning and carrying out investigations), 4 (analyzing and interpreting data) and 8 (obtaining, evaluating, and communicating information). However, student participation differed across SEPs, as did their teachers' CLRT implementation. Though CLRT has known benefits for multilingual learners in science classrooms, this work provides new insights on the potentials for Science Education for the Rest of Us by demonstrating a relationship between CLRT and student participation in SEPs.

Game On:Facilitating Students' Interest in Gaming as a Vehicle for Science Learning
Justice Ejike*, Georgia State University, USA
Natalie King, Georgia State University, USA

ABSTRACT
This study investigated the use of Game-based Learning (GBL) to introduce young scholars to physics. We present case studies of three Black boys who participated in a 4-week summer STEM program in partnership with a mobile game truck. The findings revealed that these scholars not only developed deep and meaningful insights into Newton's Laws but also demonstrated a heightened interest and enjoyment in the learning process. Additionally, a strong sense of belonging emerged among the participants, fostering a supportive and inclusive learning environment. We highlight the brilliance and creativity of these young scholars, and we posit the need for continued reimagination of education--particularly for young Black boys who may not always see themselves (or their interests) represented in STEM.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Innovations in Teaching and Analysis Strategies
19-Mar-24, 2:30 PM-4:00 PM
Location: Governor's Square 17

Using Natural Language Processing to Analyze Students' Problem-Solving Strategy Essays
Winter Allen*, Purdue University, USA
Jeremy Munsell, Purdue University, USA
Carina Rebello, Toronto Metropolitan University, Canada
Sanjay Rebello, Purdue University, USA

ABSTRACT
Recent advances in natural language processing (NLP) and machine learning (ML) have enhanced the promise for individualized assessment and feedback in online instruction. In an online quiz taken by students in a large-enrollment calculus-based course at a large Midwestern University, students solved a "ballistic pendulum" physics problem. After solving the problem and selecting their answer from the multiple-choice options, they were asked to write an essay describing their problem-solving strategy. Student strategy essays were analyzed using NLP and ML methods. Essays from two non-consecutive spring semesters

were used for training/validation (N=1480) and testing (N=1441) in the ML algorithm. For the training/validation set, student essays were labeled using two methods. First, using the binary correctness of student answers to the multiple-choice question. Second, using codes from trained human raters with sufficient interrater reliability. The accuracy in predicting students' correctness was tested and compared between the two methods of labeling the training set. We report on the different prediction accuracies of the ML algorithm and discuss its potential contributions to the teaching and learning of science.

Navigating the New Frontier: Testing an Approach for Enhancing AI Awareness Among Non-STEM Undergraduates

Rebecca Zulli*, Cynosure Consulting LLC, USA
Adrienne Smith, Cynosure Consulting LLC, USA
Sambit Bhattacharya, Fayetteville State University, USA
Xiaochen Hu, Fayetteville State University, USA
Zahra Shekarkhar, Fayetteville State University, USA

ABSTRACT

AI's pervasive influence surpasses STEM boundaries, impacting various sectors. Prioritizing AI trustworthiness in education equips students with skills for critically evaluating AI bias, transparency, relevance, and ethical considerations. Informed by literature review and expert faculty from CS and CJ, this study identified three focal AI awareness constructs: AI knowledge (definition, development, relevance in criminal justice), AI processes (inputs, perception, technical skills for criminal justice), and AI's impact (social, ethical, discipline-specific use in criminal justice). The study designed, implemented, and tested a specialized AI trustworthiness course module for criminal justice students attending a HBCU. Incorporating Process Oriented Guided Inquiry Learning (POGIL) with ChatGPT as a real-world AI example, the module engaged students in AI exploration, emphasizing Large Language Models. POGIL activities enhanced nuanced AI trustworthiness understanding within criminal justice. The course promoted practical AI application comprehension, fostering critical thinking and collaboration. Pre- and post-module assessments informed by diverse criminal justice prompts assessed effectiveness. Statistical analyses revealed improved AI literacy and ethical awareness, evidencing the intervention's impact on AI trustworthiness among HBCU criminal justice undergraduates and demonstrating broader potential for interdisciplinary AI education. This prepares a more informed, ethically conscious generation to navigate the evolving technological landscape.

Johnstone's Triangle as a Lens for Teaching With Case Studies in Undergraduate Classrooms.

Ally Hunter*, University of Massachusetts, USA
Melissa Zwick*, Stockton University, USA

ABSTRACT

Many biological topics are difficult to learn and teach. However, today's world requires that we all have a basic understanding of biology to navigate and participate in society. Decades ago, in chemistry education, Johnstone gave us a framework (Johnstone's Triangle) to

explain the complex nature of scientific concepts and why they are difficult to learn. Johnstone described the multi-level understanding many concepts require, including the macro world (things we see/sense), the sub-micro world (things we cannot see), and the symbolic language used to convey scientific meaning (i.e., chemical equations). This multi-level understanding illustrates the gap between the expert scientist who can easily shift between and utilize multi-level understanding and the novice student who is only just mastering these multiple domains. Here, we apply Johnstone's triangle as a new lens for examining case study pedagogy for life science classrooms. We discuss our framework for case study pedagogy and how the application of Johnstone's triangle can be a way to develop better case studies for teaching, increase faculty understanding of how to develop and deploy case studies more effectively, and broaden our understanding of how to facilitate student understanding of hard-to-learn scientific concepts.

Analyzing How Supplemental Instruction Impacts Student Motivation in an Introductory Organic Chemistry Course for Non-Majors

Michael Guyot*, University of Florida, USA
Samantha Hsu*, University of Central Florida, USA
Javlon Nizomov, University of Florida, USA
Pavlo Antonenko*, University of Florid, USA
Stefanie Habenicht, University of Florida, USA

ABSTRACT
This study investigates the effect that Supplemental Instruction (SI) has on students' learning outcomes and motivation in an introductory Organic Chemistry course for non-majors. We measured its impact by analyzing data on student engagement during SI sessions, course grades throughout the semester, and self-reported motivation levels. Our preliminary findings showed improvements in certain exam scores for students participating in SI, which is aligned with prior studies. However, further analysis showed that student motivation, rather than SI status, could be driving these improvements. These results suggest that while SI could be beneficial for some students, more effort should be placed into ensuring that students are motivated to learn difficult concepts. Further studies should be completed to determine the genesis of increased exam scores for those participating in SI studies. At this moment, there is not enough data to prove whether this increase comes from SI participation alone, or some external factor such as student motivation.

Using fictionalized student dialogues to investigate students' exploration of alternative perspectives

Thanh Le*, Western Washington University, USA
Carolina Alvarado, California State University, Chico, USA
Andrew Boudreau, Western Washington University, USA
Jayson Nissen, Nissen Education Research and Design, USA

ABSTRACT
Student-centered, research-based materials often use fictionalized student dialogues (FSDs) to present multiple perspectives on a phenomenon. These perspectives come from research

on common student ideas for physical phenomena. We applied a socio-metacognitive framework to investigate how students explored the alternative perspectives presented by an FSD. The FSD presented three fictitious students' ideas about the motion of a cart that received pushes from a hand. Analysis of classroom videos of 17 groups engaged in the activity indicated that 10 groups engaged with two or three of the three presented perspectives. Three of these groups engaged in high scores of exploring the alternative perspectives presented by all the fictionalized students. We present a case study of one of these groups who stood out because they discussed each of the three ideas and started their discussion by focusing on who they disagreed with. FSDs can support students engaging in high scores with alternative perspectives. FSDs are, however, insufficient on their own to get most groups to explore the alternative perspectives presented in the FSD.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Supporting and Exploring What it Means to Teach in Equitable Ways
19-Mar-24, 2:30 PM-4:00 PM
Location: Plaza Court 4

Expanding Pre-Service Teachers' Anti-Deficit Noticing Abilities Using an Iterative Classroom Design

Alison Mercier*, University of Wyoming, USA
David Steele*, Alder Graduate School of Education, USA
Tierney Hinman, Auburn University, USA

ABSTRACT

Structural inequities operate, in part, on deficit-based approaches to education, including the assumption that students from historically marginalized communities cannot do sophisticated science; on the other hand, anti-deficit approaches recognize and value diverse ways of knowing and existing in science. This design-based study examined the use of intentionally designed coursework to support pre-service teachers' anti-deficit noticing practices and their capacities to attend to students' ideas and interpret those ideas as meaningful. Researchers examined pre-service teachers' noticing of elementary students' explanations of scientific phenomena as captured in written notebook reflections and small- and whole-group discussions through a series of embodiments (i.e., iterations with intentional design changes) targeting expansion of anti-deficit noticing. This presentation focuses on the second embodiment – shifting discourse and discussion structures. Data demonstrated that shifting discussions from whole group to small group settings expanded opportunities for PSTs to not just name what they noticed in the videos but to also explore their interpretations of the details they attended to. Findings have implications for the design of protocols for use in teacher education programs that strengthen PSTs' anti-deficit noticing practices for more equitable science instruction.

Supporting Equitable Noticing in Elementary Science Methods Courses

Ashlyn Pierson*, The Ohio State University, USA

Andrea Henrie*, Vanderbilt University, USA
Mutiara Syifa*, The Ohio State University, USA
Teo Keifert*, University of North Texas, USA
Sophia Jeong*, The Ohio State University, USA
Heather Johnson*, Vanderbilt University, USA
Bethany Daniel, Vanderbilt University, USA
Sarah Lee*, Vanderbilt University, USA

ABSTRACT
Educational researchers have increasingly attended to equity as a priority. While multiple conceptions of equity exist in STEM education, we conceptualize equitable science teaching as generating and valuing multiple perspectives of phenomena, including through epistemic and representational diversity. Enacting equitable science teaching therefore requires "desettling" what counts as science and science learning by foregrounding learners' ideas, values, and practices as part of science.
However, few undergraduate teacher candidates (TCs) have been exposed to this form of science teaching and learning. Furthermore, in science teacher preparation programs, equity in STEM is often addressed peripherally. When equity is not a central focus in science methods courses, TCs have few opportunities to surface and challenge deficit and assimilationist ideologies. Therefore, TCs often take additive approaches to equitable science teaching (e.g., including underrepresented "heroes and holidays") rather than "desettling" what counts as science learning.
In response, in this paper, we analyze artifacts from an elementary science methods course developed to foreground equitable noticing. This paper analyzes reflection activities and their impact on TCs' noticing, focusing on how these activities surfaced deficit perspectives and encouraged asset-based stances that value multiple perspectives of phenomena and multiple epistemic practices.

Indonesia Teacher Candidates' Noticing and Navigating Equitable Sense-making in Teaching Physics Classrooms

Mutiara Syifa*, The Ohio State University, USA
Lin Ding*, The Ohio State University, USA

ABSTRACT
Emerging teachers such as teacher candidates (TCs) are prone to notice learners' deficit ideas which may influence how they navigate sense-making moments in their classroom. Few studies have investigated TCs' anti-deficit noticing or equitable sense-making in science education, yet no study has investigated Indonesian physics TCs. Thus, this study investigates what Indonesian physics TCs notice and how they shape their sense-making moments. This study utilized a narrative case study design to analyze three Indonesian physics TCs enrolled in a field placement program. The authors found that TCs noticed and reflected upon: (a) the students' participation by building off of their prior knowledge, (b) physics teaching and learning adjusted to provide the phenomena that students need, and (c) classroom interactions upon mutual appreciation between students and teachers. Additionally, a TC's case study showed how she co-constructed a science storyline with her students by (a) adjusting the lesson plan to meet students' ways of understanding and (b) by using teacher

talk moves to invite students to share their ideas and reasoning. This study contributes to teacher noticing and equitable sense-making literature and may benefit science teacher educators and other NARST members.

Exploring Preservice Teachers' Perspectives on Equity in Science Education in an Equity-focused Science Methods Course
Wanjoo Ahn*, Michigan State University, USA
Christina Schwarz, Michigan State University, USA

ABSTRACT
This study examines how preservice teachers' perspectives on equity in science education evolved by engaging in and reflecting on equitable teaching practices in an undergraduate science methods course. This study compared two groups of preservice teachers from Fall 2022 and Spring 2023. Fall 2022 engaged in learning science content, and Spring 2023 engaged in science content with interventions promoting equity in science instruction, including Wholistic Science Pedagogy, Culturally Responsive Teaching, and Culturally Sustaining Pedagogy. Analysis of preservice teachers' views on equitable instruction, cultural relevance, and the interplay of science, race, and culture indicates substantial differences between the two groups. Preservice teachers in the equity-infused course indicate more accurate definitions of equity, awareness of the interplay between science, race, and culture, recognition of the impact of identities on science learning and teaching, and perceptions of equitable instruction in science. The study highlights the importance of explicit instruction, engagement, and reflection in cultivating equitable science teaching and learning.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Systematic Reviews in Science Teacher Education
19-Mar-24, 2:30 PM-4:00 PM
Location: Plaza Court 5

A Systematic Literature Review of Science Methods Instructors' Pedagogical Practices
Syahrul Amin*, Texas A&M University, USA
Joanne Olson*, Texas A&M University, USA

ABSTRACT
Despite decades of research on science teacher preparation, very little is known about the pedagogical practices of science teacher educators (STEs). This is of particular concern since researchers have identified the teacher as the most influential classroom-based factor that affects student achievement, and the same relationship likely exists in teacher preparation programs. To this end, we conducted a systematic literature review (SLR) to determine: 1) what trends exist in the STE research, and 2) what is known about the pedagogical practices of STEs for the preparation of science teachers' pedagogy to teach science. We conducted systematic searches across five databases (e.g., ERIC via EBSCO, PsycInfo, Web of Science, ProQuest, and ScienceDirect), and yielded n=54 empirical and theoretical articles. The review

highlights that most studies focused on outcomes such as but not limited to exploring STEs' professional knowledge bases, experiences, preparedness, perspectives, conceptions, beliefs, and attitudes in science teaching, primarily through qualitative approaches. Surprisingly, very few studies centered on the pedagogical practices of STEs that utilized classroom observations and videotaping. Moreover, the review reveals a discernible gap in the literature regarding STEs, which necessitates further research examining the STEs' pedagogical practices with sufficient granularity or proximity to actual classroom practices.

Systems Thinking in Science Teacher Education: A Systematic Review
Samia Khan*, University of British Columbia, Canada
Moritz Krell*, IPN – Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
The objective of this systematic review is to explain the current state of the research on preservice science teachers and systems thinking. Systems thinking is the ability to recognize, describe, and model the structure and behavior of a complex phenomenon. The literature in science teacher education was reviewed following PRISMA guidelines, using Covidence software. Forty articles were eligible for this review. Two coders reviewed each article independently and achieved a Cohen's K of 0.79. Risk of bias was addressed using two coders and the MMAT. Additionally, a codebook was continually refined, reaching 83% agreement on first round of coding. Following a configurative and aggregative synthesis approach, coding of the articles yielded themes pertinent to systems thinking and science teacher education. These themes are codified as types of systems researched in preservice teacher education, definitions of systems thinking, professional knowledge that tends to be researched on systems thinking in science teacher education, and characteristics of interventions studied. The current state of the research suggests that this area has burgeoned in the last decade. Opportunities to provide definitional clarity, address physical systems, and foster assessment of systems knowledge; however, remain relatively under-explored areas in science teacher education.

Promoting a Healthy Stress Response: A Systematic Review of Using Mindfulness with Pre-Service Teachers
Anne Levendusky*, University of Florida, USA

ABSTRACT
Despite the demand for science educators, there continues to be a shortage due to high turnover rates and attrition. One contributing factor to this phenomenon is burnout fueled by emotional exhaustion. Research has been conducted with in-service educators and students; however, more attention has recently been put into proactively addressing the issue by improving the emotional and mental health of pre-service teachers. This systematic review evaluated empirical studies to identify, within teacher preparation programs, a) why mindfulness is being used, b) how mindfulness is being used, and c) the noted outcomes or benefits of the practices. Multiple databases were utilized to isolate sixteen studies conducted between 1979 and 2021 with inclusion criteria consisting of empirical studies focused on implementing mindfulness with pre-service teachers within a formal teacher

preparation program. Undergirded by Polyvagal Theory, results suggest that mindfulness programs are being implemented for the main purposes of stress/anxiety management and enhancing well-being; primary practices within mindfulness programs include meditation, breathwork, and mindful movement; and the primary outcomes/benefits noted included stress/anxiety reduction, emotion regulation/articulation, and utilizing mindfulness in the classroom. Using these results, implications for science teacher preparation are proposed, and research gaps and opportunities are identified.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Growing and Supporting District and Teacher Leadership
19-Mar-24, 2:30 PM-4:00 PM
Location: Governor's Square 12

Initial Growth of Inclusive Knowledge and Leadership Practices by Science Education Teacher-Leaders
Elizabeth Lewis*, University of Nebraska-Lincoln, USA
Elizabeth Hasseler, University of Nebraska-Lincoln, USA
Rachel Benzoni, University of Nebraska-Lincoln, USA
Gina Matkin, University of Nebraska-Lincoln, USA

ABSTRACT
Since 2021, we recruited 20 in-service science teachers from 12 school districts to become National Science Foundation Noyce Master Teaching Fellows (MTFs). Our core research question is: What are science teachers' initial needs, capacity for learning, and group-level change in cultural competence to be a teacher-leader? In response, we have focused on Noyce MTF Cohort 1's 11 teachers, to provide insights into the recruitment and professional development of science teacher-leaders. Our project partners include one urban, one suburban, and one rural school district, and two non-profit partners (a statewide science teacher professional association and the state's department of education). We share the results of: (a) our Educational Specialist (Ed.S.) degree program with personal leadership certificate design and recruitment results, (b) administering the Intercultural Development Inventory® survey at pre-program and post-Phase I program milestone, (c) an analysis of state science teaching endorsements, and (d) an inventory of initial leadership activities. We found that teacher recruitment was possible, but on a longer timeline, the beginning of the degree program and National Board Certification process needed to be staggered, and that our strong programmatic focus on diversity, equity, and inclusive teaching was effective in positively shifting the group's cultural competence.

Exploring the Formative Experiences of District Science Coordinators
Khushbu Singh*, Clemson University, USA
Jennifer Bateman, Clemson University, USA
Meredith Schwendemann, Clemson University, USA
Brooke A. Whitworth, Clemson University, USA

ABSTRACT
This study explores the formative experiences of District Science Coordinators (DSCs) through a collective case study approach. Employing the lens of critical reflection, the research delves into the challenges encountered by DSCs during their early leadership years. Data sources comprise the Formative Leadership Experience Survey (FLEX), subsequent semi-structured interviews, and thematic analysis of the interview data from seven participants with 1-4 years of experience. The findings illuminate the hurdles of navigating uncertainty and adaptability, grappling with a lack of support and mentorship, and addressing the intricate challenges of leading science education reform.This research sheds light on the transformative journey of DSCs, unveiling insights into their professional growth and the implications for educational leadership and support.

Exploring District Science Coordinators' Learning

Brooke Whitworth*, Clemson University, USA
Jennifer Bateman, Clemson University, USA
Meredith Schwendemann, Clemson University, USA
Khushbu Singh, Clemson University, USA
Hatice Ozen, University of Georgia, USA
Ashley Hunter, Clemson University, USA
Julie Luft, University of Georgia, USA

ABSTRACT
This proposal explores the learning of District Science Coordinators (DSCs) through a comprehensive two-year Professional Learning (PL) program. By focusing on equity, leadership, Next Generation Science Standards (NGSS) practices, and professional learning, this study aims to uncover the evolution of DSCs' leadership learning. The theoretical framework, grounded in Situated Learning Theory and Bronfenbrenner's Ecological Systems Theory, delves into the complex interplay between DSCs, their learning environment, and the broader educational landscape. Employing a mixed-methods approach, combining quantitative tools (surveys) and qualitative methods (interviews, artifacts, focus groups), this study captures a comprehensive understanding of DSCs' learning experiences. Two cohorts of DSCs were engaged in a synchronous online PL program, with initial findings suggesting significant growth in equity-related knowledge and strategies. Moreover, DSCs reported increased confidence in leadership roles, evident in their strategic plans and statements. Ongoing analysis will further illuminate NGSS practices and professional learning aspects. This research contributes to an underexplored domain, enhancing insights into DSCs' learning and their impact on science education. The outcomes hold implications for policy enhancement and refining support systems for DSCs.

Contributions of Race on a STEM Teacher Leader's Self-Efficacy, Agency, Values, and Teacher Leadership

Damaries Blondonville-Ford*, Morgan State University, USA
Diana Cheng, Towson University, USA
Derrick Grubb, Morgan State University, USA

Justin Leonard, Prince Georges' County Public Schools, USA
Xiaoyin Wang, Towson University, USA

ABSTRACT
Increasing the interest and academic performance of students of color in STEM is essential to obtaining diversity in the STEM workforce. Competent K-12 STEM educators of color are critical to building interest in STEM content areas among students from diverse backgrounds. STEM teacher leaders of color can be instrumental in developing and retaining STEM teachers of color and developing cultural responsiveness in their White and Asian colleagues, especially in urban communities. However, how to best develop teacher leaders is still being understood. Using modified items from several surveys, data was collected from STEM teachers in urban school districts on teacher self-efficacy, agency, and values and their impact on STEM teacher leadership. Using roles and race as a factor, respondents' responses were compared using a chi-square test. Significant and direct relationships were found between race, self-efficacy, values, role, and teacher leadership. This study can be used to inform STEM teachers' professional learning and development and supports the need for creating a pipeline for Urban STEM teacher leaders.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Investigating and Supporting STEM Teaching and Learning
19-Mar-24, 2:30 PM-4:00 PM
Location: Directors Row H

Evaluation of a National Training Program of STEM-based Competencies in Oman
Mohamed Shahat*, Sultan Qaboos University, Oman
Sulaiman Al Balushi, Sultan Qaboos University, Oman
Marwa Alhinai, Ministry of Education, Oman
Mahmoud Amer, Sultan Qaboos University, Oman
Nabil Alhabsi, Ministry of Education, Oman
Khoula Alhosni, Sultan Qaboos University, Oman
Amur Al-Yahmedi, Sultan Qaboos University, Oman
Mohammed Al-Amri, Sultan Qaboos University, Oman
Sameh Ahmed, sultan Qaboos University, Oman
Ehab Omara, Sultan Qaboos University, Oman

ABSTRACT
This is a nationally funded strategic study to develop and assess a National Training Program of STEM-based Competencies in Oman. The study was conducted with a nation-wide sample of in-service basic education science teachers (N=48 with 24 males and 24 females). A test for teachers' STEM-based content knowledge and an intervention training program were developed. a Quasi-experimental design with pre/post assessment and intervention in between was used, and data were analyzed using classical statistical methods. The findings showed a significant difference between the control and intervention groups in the post-test

and demonstrated the training program's impact on teachers' STEM-based content knowledge. The development of the nation-wide intervention and instrument, the results, and contributions to the field will be reported in this paper.

Exploring Physics Teachers' Resource Networks in Technology-Enhanced Learning Environments

Jaika Hott*, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Stefan Sorge, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Marcus Kubsch, FU Berlin, Germany
Knut Neumann, IPN - Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT

The implementation of digital learning environments creates opportunities for teachers to establish new teaching and learning arrangements. To implement these arrangements effectively in the classroom, teachers draw upon resources. Yet, prior research has indicated that individual resources are insufficient and that interactions between resources as resource networks are crucial for successful implementation. However, it is unclear which resource networks effectively promote the use of digital technologies to implement innovative teaching and learning arrangements and how these depend on individual teacher characteristics.

To investigate physics teachers' resource networks in the context of digital learning environments, seven secondary physics teachers enacted a digitally-supported teaching unit centered around energy. Interviews were conducted to gather insights into the resource networks that physics teachers use during the implementation process. Based on an inductive-deductive coding, we identified a strategical use of material resources that foster the growth of teachers' pedagogical content knowledge but with different learning outcomes that depend on teachers' specific backgrounds. The findings also suggest that the use of social resources enhances teachers' technological knowledge.

The contribution provides a perspective on how to design more targeted professional development for teachers to promote an appropriate and sustainable implementation of digital learning environments in the classroom.

From Design to Practice: Secondary Science Teachers' Reflections on an Integrated STEM Observation Protocol

Emily Dare*, Louisiana State University, USA
Joshua Ellis*, Louisiana State University, USA
Chris Irwin, Florida International University, USA

ABSTRACT

This case study was designed to better understand secondary science teachers' reflections on an observation protocol for K-12 integrated STEM education by addressing the following research questions: 1) What are secondary science teachers' reactions to integrated STEM practices as measured by an observation protocol? and 2) In what ways do secondary science teachers envision using an observation protocol as a tool in their practice? A thematic analysis of four teacher participants' interview responses revealed three main themes related

to their integrated STEM teaching: already doing, not yet including intentionally, and facing barriers. Our results shed light on how to better support teachers using the protocol as a tool for formative evaluation, improvement, and planning. When considering professional learning opportunities for both pre-service and in-service science teachers, it is important to first assess what teachers are already doing, what they want to be doing, and what they believe is superfluous. This work will be of interest to individuals interested in working with and conducting research related to science teachers developing knowledge of integrated STEM education.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set
Assessments Informing Instructional Practices
19-Mar-24, 2:30 PM-4:00 PM
Location: Directors Row J

Developing Instructionally Relevant Assessments in Middle School Chemistry
Katherine Lazenby*, NWEA, USA
Gavin Fulmer, NWEA, USA
Yon Soo Suh, NWEA, USA
Rob Howard, NWEA, USA
Alexis Prijoles, NWEA, USA
Susan Kowalski, NWEA, USA

ABSTRACT
This study describes our efforts to develop an assessment for middle school chemistry that provides evidence of students' fine-grained knowledge and skills with the purpose of providing instructionally relevant insights for educators. We adopted a mixed-methods study design to develop, test, and refine a model of 7th grade student cognition surrounding chemical reactions and the relationship between properties, substances, and particles. We designed technology-enhanced assessment items that engage students in NGSS practices, such as modeling and arguing from evidence, within the context of a real-world phenomenon, the rusting of a nail.
Our findings from this mixed-methods study contribute to science education research by demonstrating an approach to using technology-enhanced, constructed-response items to provide insights into students' cognitive processes and mental models. These insights can support educators in planning differentiated instruction and offer a deeper understanding of student thinking. The study's findings and methodologies are relevant to assessment developers, educators, and researchers interested in improving science education at the middle school level.

Rethinking the Design of 3D Elementary Assessments: Considering the Role of Language in Science Learning
Alison Billman, University of California, Berkeley, USA
Jill Wertheim*, WestEd, USA

Lauren Brodsky, University of California, Berkeley, USA
Christopher Harris, WestEd, USA

ABSTRACT
The intersection between science understanding and the ways ideas are communicated has long presented challenges for equitable science teaching and learning. The use of academic vocabulary is typically privileged as evidence of science knowledge. In this paper, we present a study focused on designing three-dimensional assessments for third grade performance expectations that attend to the language registers students are using and the ways they are using them to communicate their science ideas; and intentionally shift the focus toward recognizing students' language-in-use and the ways it can be scaffolded to support the development of their knowledge-in-use. Language is framed as a structured system of communication that assists participation within the community of scientists and as a set of tools for developing scientific thinking. By framing language as more than vocabulary words, these assessments offer valuable resources for teachers to expand their repertoires for supporting students' language development overall, and also have implications for the ways we assess and support language development in later grades where technical vocabulary is prioritized.

Measuring Students 3D Learning and Transfer Using NGSS-Designed Life Science Assessments

Consuelo Morales*, Michigan State University, USA
Jane Lee*, Michigan State University, USA
Emil Eidin*, University of Wyoming, USA
Peng He, Michigan State University, USA
Irene Bayer, Michigan State University, USA

ABSTRACT
Assessments that measure 3D learning are important because it demonstrates that students can and do learn this way. Additionally, assessments that present varied but similar phenomenon can further demonstrate students' ability to transfer learning from one context to another. The purpose of this research is to investigate how a set of NGSS-designed life science assessments support middle school students to further their three-dimensional (3D) learning and apply it into a new context. This study presents preliminary statistical analysis and qualitative examples from 20 students' pre, middle (lesson-embedded), and post assessment work. The result shows a significant difference between the pre and middle, and pre and post assessments. This indicates students were able to gain 3D knowledge about gene-environment interaction through the unit and make a transfer from the context of diabetes that they were studying in the unit to a new context, asthma. Student progress towards 3D learning during exposure to an NGSS-designed life science unit and learning in a new context post unit enactment was observed. Findings have implications into teaching/learning/development/research of 3D curriculum and assessments. This study illustrates student growth in 3D science learning is possible through carefully developed 3D curriculum and assessments.

Integrating Curriculum-Independent Science Assessment Tasks into Elementary Teachers' Instruction

Sania Zaidi, University of Illinois at Chicago, USA
Brian Gane, University of Kansas, USA
Debbie Leslie, University of Chicago, USA
Carla Strickland*, University of Chicago, USA
Jeanne DiDomenico*, University of Chicago, USA

ABSTRACT

We employed research-based evidence to construct effective professional learning communities tailored for teachers, with a primary focus on fostering NGSS-aligned formative assessment practices within elementary classrooms. Within this framework, we investigated how our collaborating teachers integrated curriculum-independent, multidimensional science assessments into their instruction. By employing thematic analysis of the questionnaire responses, we discern two predominant themes: (1) Strategic Curriculum Integration: Teachers invested significant time and effort in planning the integration of assessment tasks into their existing curriculum and instructional practices,(2) Emphasis on Student Engagement and Collaboration: Teachers placed a strong emphasis on assessing the success of task enactments through student engagement, lively discussions, and collaborative interactions. These findings have the potential to offer insights to other assessment and professional learning developers working within the domain of formative use of assessments in science education.

Strand 11: Cultural, Social, and Gender Issues
Symposium
A Multidimensional-Multiplicative Approach to Examining Blackness in STEM
19-Mar-24, 2:30 PM-4:00 PM
Location: Plaza Court 3

A Multidimensional-Multiplicative Approach to Examining Blackness in STEM

Terrell Morton*, University of Illinois Chicago, USA
Paula Price, North Carolina A&T State University, USA
Ashley Woodson*, Albion College, USA
Tia Madkins*, University of Texas Austin, USA
Yasmiyn Irizarry, University of Texas Austin, USA
Nickolaus Ortiz, Georgia State University, USA
Shari Watkins, American University, USA
Andrea Tyler, Tennessee State University, USA
Brain McGowan, American University, USA
Jennifer Adams, University of Calgary, Canada

ABSTRACT

Research, policies, and practices in postsecondary STEM that strive to enhance the experiences and outcomes of Black students often do not account for the heterogeneity of

Blackness. As a racial identity, Black people are presumed to be a homogenous group, therefore having research outcomes, policies and practices that presume that all Black people are the same and require the same resources. This homogenous perspective of Blackness reifies oppression and equates Black people to being anti-human. In this symposium we discuss research that strives to disrupt anti-Blackness in STEM education by theorizing and investigating Blackness in STEM through a multidimensional-multiplicative approach.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Science Teachers' Perspectives and Practices: Noticing Inequities, Envisioning Social Justice, and Enacting Decolonial Pedagogies
19-Mar-24, 2:30 PM-4:00 PM
Location: Governor's Square 14

Teachers' Noticing of Science During Facilitated Equity Debriefs
Linsey Brennan*, Michigan State University, USA

ABSTRACT
The culture of exclusion has been well-documented within science education (e.g., Bang et al., 2013; Calabrese Barton & Tan, 2020) and limits students opportunities to learn science and view themselves as a science person (Carlone et al., 2011). A multilayered approach that considers the macro (systems), meso (epistemologies), and micro (moment-to-moment interactions) layers, interactions between them, and the influences of societal ideologies is necessary to make science education more equitable (Burgess & Patterson Williams, 2022). This study seeks to explore the nature of two teachers' noticing (micro layer) of science (meso layer) during facilitated equity debriefs, as well as shifts in their noticing over time. Videos of the teachers were recorded as they participated in debrief sessions with a researcher, trying to make sense of inequitable patterns of participation within their classroom (as observed using EQuIP analytics). The teachers' noticing aligned with Western Modern Science (WMS), particularly narrow definitions of who is a scientist, what it means to "do" science, and "productive" interaction types for learning science. These findings highlight the influence of WMS on teachers' noticing and the importance of explicitly challenging WMS during equity-oriented professional development to support teachers in (re)framing dominant cultural frames.

Teaching and Learning Science as Social Justice: Perspectives of Students and Teachers
Katie Wade-Jaimes*, University of Nevada, USA
Maizie Dyess*, University of Nevada, USA
Burak Sahin*, University of Nevada, USA

ABSTRACT
In this proposal, we examine how teachers and students in secondary science classrooms experience "teaching science for social justice." As part of a larger study, teachers

participated in ongoing professional development related to teaching science for social justice using the lens of identity development. Data collection included professional development artifacts and discussions, teacher interviews, student interviews, and classroom observations. Three teachers were chosen as the focus of analysis, and four-six students interviewed in each teachers' class. Specifically comparing the perspectives of students and teachers, data analysis revealed three themes: a disconnect between what teachers and students identified as relevant in science, the importance of authentic relationships, and disparities in how teachers and students positioned students with respect to science. The results indicate a need to explicitly prepare teachers to incorporate antiracist and culturally relevant pedagogies in order to provide meaningful support for students' science identity development. Additionally, including student perspectives on classroom activities is crucial to understand the actual, as opposed to perceived by teachers, impact of teacher actions on students' science identities.

Colorado Science Education Research

Does "Teaching Science for Social Justice" Change Over Time for Science Teachers?

Jessica Mader*, Colorado State University, USA
Laura Sample McMeeking, Colorado State University, USA
Andrea Weinberg, Arizona State University, USA
Diane Wright, Colorado State University, USA
Madison Scheer, Dawson School, USA
Meena Balgopal, Colorado State University, USA

ABSTRACT

Confidence and beliefs about how to teach science for social justice (SSJ) transforms with experience. In recent years, teachers have reimagined what teaching SSJ means, considering recent political, social, and public health events. In this qualitative study, we recruited 13 science teachers in 2017 and asked them to record themselves teaching any lesson and complete an analytical reflection of practice, paying attention to social justice and meeting all students' needs. The same teachers were asked in 2023 to rewatch their 2017 videos, complete another analytical reflection of practice, as well as be interviewed about how their motivations, confidence, and understanding of what teaching SSJ may have changed. To identify patterns in teachers' motivations to teach SSJ, we used expectancy values theory, which explains that one is motivated by both their expectations for success and their values regarding the importance, desirability, utility, and cost of the task. We used reflexive thematic analysis and found that participants all described more intentional approaches of teaching SSJ over time. They were most motivated by their own increased expectations for success and stronger values pertaining to the importance and need to teach SSJ, although some felt it was costly to be explicit about their intentions.

Culturally Relevant STEM Education in Nigeria: An Exploratory Study of STEM Teacher Ideas About Teaching

Grace Tukurah*, Michigan State University, USA

ABSTRACT
The school science curriculum in Nigeria has origins in colonial prescriptions and despite the reauthoring of curricula post colonization, the structure and methods of teaching still maintain some of their initial colonial characteristics. Using a framing of culturally relevant pedagogy in STEM teaching, this exploratory study examines the ideas that secondary STEM teachers in Nigeria hold about teaching their courses in culturally relevant ways. There were 73 teachers who completed an anonymous survey about their teaching beliefs which included Likert scale questions and open response questions. The findings of the study provided insights to the ways that secondary STEM teachers in Nigeria were thinking about their respective roles in the classroom and the most effective ways to teach their courses. The implications of this allow for those seeking to advocate for culturally relevant and decolonial science pedagogy to understand how teachers are thinking about these issues as they work alongside the teachers.

Strand 14: Environmental Education and Sustainability
Related Paper Set
Frameworks and Considerations for Justice-Oriented, Place-based Learning
19-Mar-24, 2:30 PM-4:00 PM
Location: Governor's Square 10

Social Justice as Paradigm and Pedagogy

Bryan Brown, Stanford University, USA
Kendra Sobomehin*, Stanford University, USA
Tamara Sobomehin, Stanford University, USA

ABSTRACT
The adoption of modern educational technology has been limited by how well EdTech tools align with a teacher's pedagogical goals for science teaching. Research on virtual reality in K-12 learning environments suggests that VR has the potential to promote effective learning and promote greater engagement. Using the Technological Pedagogical Content Knowledge (TPCK) theory, we explored how different pedagogical uses of virtual reality produced different outcomes. This qualitative analysis of 45 virtual reality videos created by 9th grade Biology students revealed how individual, small group, and large group pedagogical approaches to using VR altered how students interacted with the media and applied scientific ideas. The results of this study provide insights into how edtech tools, like virtual reality, can achieve different goals based on teachers' pedagogical decisions.

A Systematic Literature Review of Climate Change Education Studies Using Place-Based Theoretical and Pedagogical Frameworks

Asli Sezen-Barrie*, NSF, USA
Sara Tolbert, University of Canterbury, New Zealand

ABSTRACT
Climate change's global ramifications have disproportionately affected local communities and prompted heightened awareness and concern, specifically among youth facing exacerbated impacts. In response, educators adopted place-based frameworks, leveraging community ties and land relationships for effective climate change learning. This study employs a systemic literature review to synthesize climate change education studies, underlining place-based theoretical and pedagogical approaches across disciplines. The review takes a transdisciplinary approach to climate change education while looking at studies in science education, environmental education, and science communication. The findings of this study underscore the criticality of place-based education in fostering learners' knowledge of changing climates, socioecological reasoning, care, ecoanxiety, and place identity. These outcomes span diverse communities, encompassing formal schools, informal learning spaces, parks, and media platforms. Educational institutions emerge as sites for integrating place-based climate events into science curricula, media programming for youth, and as platforms for community engagement in climate action. As the Intergovernmental Panel on Climate Change's reports heighten the call for action, scholars and educators increasingly engage with climate change education. The review's insights guide place-based theories and pedagogical strategies to enhance climate change learning in science education, illuminating pathways for meaningful instruction and engagement across various learning contexts.

Sociopolitically-Conscious Science Teaching in the Garden
Christopher Jadallah*, UCLA, USA

ABSTRACT
School and community gardens are increasingly being recognized as valuable sites for science teaching and learning, making it an opportune time to identify and develop key practices for justice-oriented science education in garden settings. To work toward this goal, we conducted semi-structured interviews with 25 garden educators of color in California to examine the sociopolitical commitments informing their pedagogy. We leverage the concept of political clarity – defined as forms of critical consciousness enacted through the pedagogical work of science educators – as a guiding theoretical perspective (Madkins and McKinney de Royston, 2019). Engaging in participatory analysis with study participants, we worked to collectively identify key themes and patterns in how garden educators of color demonstrate political clarity. Results indicate that educators bring strong sociopolitical commitments to their work, articulating forms of political clarity that are unique to garden settings. Nearly all participants indicated efforts to center ancestral land-based knowledges for students of color, unsettle nature-culture relations, attend to historical land-based traumas for different groups, and integrate analyses of food and land sovereignty in their work. Ultimately, we synthesize these results to present a framework for justice-oriented science pedagogies to center the social, political, and natural contexts of garden-based learning environments.

Centering Racial Equity and Values-Based Research in Preservice Science Teacher Education in Undergraduate STEM Courses

Carrie Tzou, University of Washington Bothell, USA
Veronica Cassone McGowan*, University of Washington Bothell, USA
Symone Gyles, University of Washington Bothell, USA
Bryan White, University of Washington Bothell, USA
Elizabeth Starks, University of Washington Bothell, USA
Megan Bang, Northwestern University, USA

ABSTRACT
The natural sciences are increasingly recognizing the need to address social theories in the study of natural systems and engage learners in models of values-based research and ethical decision-making as a part of doing science. We used design-based research to iteratively codesign a 2-quarter "science for elementary teachers" course, designed to take the place of science content courses typically required for entry into teacher certification programs. These courses included four justice-centered STEM modules for learning: engineering ethics, health justice, sun-moon-earth systems, and socioecological time. We used project-based learning that centered on values-based research and critical speculative design to engage preservice educators in envisioning more just futures for socioecological and sociotechnical systems. Our findings show that through critical speculative design and ethical decision-making frameworks, students not only found narratives of hope and possibility for more socially and ecologically just futures, but also described more expansive notions of how they see science and engineering as fields of study. Here we show the value of speculation for transforming presents that pave the pathway to more just futures in science and engineering, and that STEM courses centering racial equity can and should be foundational to science teacher education and preparation.

The Connect-Investigate-Interrogate-Act Framework for Designing and Studying Critical Place-based Learning

Heidi Carlone*, Vanderbilt University, USA
Jingyi Chen*, Vanderbilt University, USA
Hannah Ziegler*, Vanderbilt University, USA
Liwei Zhang, Vanderbilt University, USA
Zachary Conley, Vanderbilt University, USA
Yelena Janumyan, Vanderbilt University, USA
Tessaly Jen, Vanderbilt University, USA
Blaine Smith, Vanderbilt University, USA
Quinn Tanner, Vanderbilt University, USA

ABSTRACT
We designed the Connect-Investigate-Interrogate-Act (CIIA) framework for integrating justice-oriented, place-based learning at a think tank with 20 teachers, teacher educators, scientists, and community leaders. We used the CIIA framework to co-design and study an urban forestry unit for 55 middle schoolers, focusing on local urban tree canopy and urban heat islands (UHI). The purpose of this study was to 1) investigate youths' engagement as

critical inquirers and potential advocates, and 2) iterate on the framework based on youths' engagement. The CIIA Framework included: 1) Connecting youth to urban trees and green spaces with a place-based learning lens; 2) Investigating city parks using urban forestry, environmental sociology, poetry, storytelling, movement; 3) Interrogating issues of justice and equity related to urban heat island and tree canopy; 4) Action through creating multimodal stories. Youth competently engaged in all aspects of the framework, though we note important design considerations for the next enactment, including: 1) accounting for youth positioned differently in relation to the urban tree canopy; 2) youths' sadness and anger about companies', government's, and adults' "lack of caring" or motivation to act on a problem that "does not affect them" or "generate profit"; and 3) the cultivation of critical civic literacy.

Leveraging Place-based Instruction for Climate Justice Education

Amal Ibourk*, Florida State University, USA

ABSTRACT

This paper aligns with ways of thinking about justice-centered teaching from an ecological justice curriculum design but also ecological justice and ways to empower teachers in their own spaces to take up climate justice work by using adaptation strategies. The conclusions from this study highlight the value of place-based science instruction that centers on justice-place-based anchoring phenomena but also the iterative process of co-authoring and co-designing with teachers as part of their navigational capital. Drawing from the framework from ten strands, this paper will share steps to create a phenomena-based justice-centered unit that elementary teachers used around the phenomenon of the monarch butterfly migration. Findings highlight also that when teachers and students understand the ecology and diversity of a place and see the web of relationships among human and non-human entities it supports, they appreciate and have a sense of kinship with their surroundings.

Collaboration for Local Sustainability: Indigenous Community Guided Transformative Science in a High School in Nepal

Aguwa Aguwa, Thakurdwara, Nepal
Bhaskar Upadhyay*, University of Minnesota, USA
Kamal Koirala, Tribhuvan University, Nepal

ABSTRACT

In this paper we explore the active influence of the Tharu community elders on current science teaching and learning in a high school with majority Tharu Indigenous students in Nepal. The school teachers had been working towards building resources and adjusting the National Curriculum so there was greater compatibility between local issues of sustainability and science contents. We draw from the ideas of green governmentality, place attachment theory, and transformative learning. The data for the study were collected over 4 years through meeting notes (8), interviews (with 3 elders, 4 teachers, each lasting between 60-90 minutes), workshops (two teacher workshops), and classroom observations (12). The findings show that Indigenous communities have agency to influence science curriculum, local

climate sustainability issues are bridge builders between science and local knowledge, teachers and community are partners in transformative science engagement.

Supporting Justice-Oriented and Community-Based Environmental Action through Near-Peer Mentorship, Geospatial Technology, & Digital Media Storytelling
Laura Cisneros, University of Connecticut, USA
Todd Campbell*, University of Connecticut, USA
Nicole Freidenfelds, University of Connecticut, USA
Anna Lindemann, University of Connecticut, USA
Heather Elliot-Famularo, University of Connecticut, USA
Cary Chadwick, University of Connecticut, USA
David Dickson, University of Connecticut, USA
Byung-Yeol Park, University of Connecticut, USA

ABSTRACT
Environmental challenges disproportionately impact under-resourced communities and communities of color (environmental justice communities). Empowering and amplifying the voices of these communities are critical to developing equitable solutions. We describe an E-STEAM (Environmental, Science, Technology, Engineering, Arts, Mathematics) approach to engaging high school teams from environmental justice communities in the development of environmental solutions and science communication/advocacy with the support of near-peer mentors and community partners. Our Eco-Digital Storyteller (EDS) model incorporates: 1) authentic community engagement practices to support high school teams during the co-design of community-based environmental action projects with near-peer undergraduate student mentors and adult community partners, 2) disciplinary knowledge in environmental science and geospatial technology to explore environmental and social data at multiple scales and identify assets (opportunities) and hazards (challenges) to center their community-based project, and 3) digital media storytelling for teams to share their rich cultural E-STEAM narratives and advocate for justice-oriented environmental solutions. EDS leverages community-based action, state-of-the-art technology, and storytelling as entry points for engaging learners, with the aim of increasing participants' E-STEAM identity. We provide examples of EDS projects/digital media presentations to exemplify the powerful ways that participation in and communication of environmental action can contribute to more sustainable, equitable futures.

Poster Session B
19-Mar-24, 4:15 PM-5:00 PM
Location: Plaza Foyer

Strand 1: Science Learning: Development of student understanding
The Science Teachers´ Perspective on the Disciplinary Core Idea Map of Genetic Variation
Helen Semilarski*, University of Tartu, Estonia
Helin Semilarski, University of Tartu, Estonia

ABSTRACT
Because of their fragmented understanding of genetic variation and inability to understand how related knowledge is interrelated, students struggle to conceptualize genetic variation. Considering that genetic variety is a fundamental and disciplinary core idea in biology, this is very troubling. Genetic variation ought to be taught in biology classes at schools, especially when studying human genetics because it may have implications for human welfare. The exploration and characterization of the genetic variation to many human diseases is one benefit of studying human genetic diversity, thus it is essential to have a clear understanding of this field's concepts and how these are interconnected. It is crucial to provide the connections between the understanding of genetic variation for both science teachers and students. This study uses a created core idea map and research science teachers´ opinions on the map to track the conceptual growth of genetic variation over the course of the educational years (from grade 1 to grade 12). It is suggested that in order to promote students´ meaningful learning, it is crucial to incorporate created disciplinary core idea maps into the science lessons.

Strand 1: Science Learning: Development of student understanding

Student Self-Efficacy: Exploring Anxiety, Career Awareness, and Transversal Skills in Science Education

Janari Teessar*, University of Tartu, Estonia
Miia Rannikmäe, University of Tartu, Estonia
Regina Soobard, University of Tartu, Estonia
Jack Holbrook, University of Tartu, Estonia

ABSTRACT
This research investigated students' perceptions of their STEM education, focusing on their transversal skills, career awareness, science-related anxieties, and competence in core ideas. Using a sample of 133 students and deploying statistical analyses in SPSS, we identified five prominent factors encompassing Communication Skills, Information Synthesis, Collaboration, Problem-solving, and Adaptability, which collectively explained 63% of the observed variance. Results indicated higher anxieties associated with Chemistry and Physics compared to Biology and Geography. Notably, subject material complexity drove anxieties in the former, while teaching methodologies influenced the latter. Gender differences emerged in both subject anxiety and career preferences: males gravitating towards technical areas like IT and Engineering, while females showed inclinations towards Healthcare and Business. Variations were also evident across different schools, hinting at environmental or methodological influences. Students felt most competent in concepts like 'Atoms and Molecules', whereas themes like 'Energy and Energetics' proved more challenging. These insights underscore the importance of aligning teaching strategies with students' intrinsic challenges and inclinations, and the potential benefits of tailored pedagogical interventions.

Strand 1: Science Learning: Development of student understanding

Do Students Learn Better When "Thinking Periods" Are Interspersed Within Online Science Lectures?

Ella Ofek-Geva*, University of Connecticut, USA

Sarah Gilmore, University of Connecticut, USA
Ido Davidesco, University of Connecticut, USA
Kyra Conville, University of Connecticut, USA
Mary Kate Coburn, University of Connecticut, USA
Sa'ar Karp Gershon, Denmark

ABSTRACT
Many science courses in higher education rely on pre-recorded lectures, but sustaining attention throughout these lectures is challenging because attention tends to fluctuate between external and internal states. The effects of internal attention (e.g., mind wandering) on learning are unclear, with some studies suggesting that internal attention is detrimental to learning while others point to some potentially positive effects. This study examined how the insertion of internal attention ("thinking") periods during an online science lecture impacted student learning. An experimental study of 34 undergraduate students revealed that, overall, students learned better when lectures were interspersed with thinking prompts compared to when they were presented continuously. These findings can inform future development and design of online courses.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Engaging Students in Visualization for an Inclusive Learning Environment

Qingna Jin*, Cape Breton University, Canada

ABSTRACT
In current science classrooms, students' backgrounds are becoming increasingly diverse, however, science teaching continues to practice the normative discourse of knowledge, and students feel disconnected from science even more than before. This qualitative case study explored how incorporating visualization in science practice promotes student epistemic agency to create a more inclusive learning environment for all students. Data included classroom observation, interviewing students, and collecting students' drawings. Findings from this study suggested that visualization played a critical role in students' knowledge development, enabling them to take up and act with their epistemic agency by integrating diverse cultural assets and personal experiences into collective knowledge construction. Students also engaged in negotiation between Western science epistemology and everyday understanding when visualizing scientific concepts.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Preservice Primary Teachers' Perceptions of STEM-Based Teaching in Natural Sciences and Technology Classrooms

Maria Tsakeni*, University of the Free State, South Africa
Tafirenyika Mafugu, University of the Free State, South Africa
Loyiso Jita, University of the Free State, South Africa

ABSTRACT

The teaching of natural sciences and technology in primary schools presents an opportunity to use innovative approaches to teach STEM-based activities. The subject presents opportunities for learners to experience STEM-based instructional approaches in their early school years, therefore, it is essential that preservice primary school teachers are adequately prepared for the task. This study explored the perceptions of preservice teachers of STEM-based teaching in natural sciences and technology classrooms. Using a single case study design of a science and technology teaching methods course, five participants were purposively selected from a group of 42 preservice teachers. The data collected were analysed using thematic content analysis techniques. The findings indicate that the preservice teachers used natural sciences as an entry point to teach STEM and underestimated the technology component. The preservice teachers had the perception that STEM is taught through activity-based strategies while incorporating assessment for learning. Although they identified activities that could be used to teach STEM, they did not link the activities with developing specific skills in the lesson plans. The study recommends that preservice teachers be taught to link STEM activities with the development of specific STEM skills.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies

Fostering Sixth-grade Students' Science Divergent and Convergent Thinking with Augmented Reality

Ya-Ting Chuang, Taipei Municipal Taiping Elementary School, Taiwan
Yu-Ling Lu*, National Taipei University of Education, Taiwan

ABSTRACT

Previous studies have seldom employed 'augmented reality' in fostering science divergent and convergent thinking skills for elementary students. Therefore, this study aims to explore the impact of integrating 'augmented reality' into science teaching on the learning outcomes of sixth-grader in terms of science divergent and convergent thinking. The study utilized a quasi-experimental research design, involving 82 sixth-graders, with 55 students in the experimental group and 27 students in the control group. The experimental group received science inquiry instruction that combined 'augmented reality' and creativity, while the control group received creativity-based science inquiry instruction without the integration of 'augmented reality'. Data collection used the creativity assessment, comprising written test for divergent thinking, pictorial drawing test for divergent thinking, and remote associates test for convergent thinking. Data analysis methods included t-tests, analysis of covariance, and the Johnson-Neyman method. The results indicated that: 1) teaching methods integrating 'augmented reality' significantly enhanced the fluency and originality in the pictorial drawing of science divergent thinking and convergent thinking of students; 2) teaching methods integrating 'augmented reality' is significantly superior to the control group in improving the fluency of students' scientific divergent thinking, but there is no significant difference in convergent thinking between the two groups.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Instructional Strategies that Support Multidimensional, Meaningful, and Equitable Model-Based Teaching: A Systematic Literature Review

Grace Carroll*, North Carolina State University, USA
Soonhye Park, North Carolina State University, USA
Matt Reynolds, North Carolina State University, USA
Amanda Hall, North Carolina State University, USA
Laura Chalfant, North Carolina State University, USA
Scott Ragan, North Carolina State University, USA
Jason Painter, North Carolina State University, USA

ABSTRACT
This paper presents a systematic literature review of model-based teaching and learning practices since the inclusion of "developing and using models" as a science and engineering practice (SEP) in the Next Generation Science Standards. Previous science education documents highlighted the significance of models in scientific inquiry, yet science teachers often struggle to go beyond using models solely for illustration. The review identifies strategies promoting multidimensional, meaningful, and equitable modeling, considering their manifestation across science disciplines and grade bands. Moreover, the study explores the integration of modeling with other SEPs and explores the impact of technology on modeling practices. The findings have implications for improving model-centered instructional models, supporting science learning for all students, and guiding future research in the field.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Collective PCK of Teachers Using American Sign Language to Teach Science With Deaf Students

Scott Cohen*, Georgia State University, USA

ABSTRACT
There is a scattered understanding of developing and sustaining science teachers working with deaf students, but there has not been much interdisciplinary work where scholars in pre-service and in-service science teachers' training and development intersect with this specialized group of teachers. This study is part of the mixed-methods dissertation study with both qualitative and quantitative findings to reveal the Refined Consensus Model for this specialized group of teachers. The findings compared the responses from science teachers of the deaf to NSSME to discuss the implication. Much of the research in science education focuses on abled-bodied students, predominantly white middle-class suburban students, which does not paint the proper picture of the dire condition of including all students to learn science as knowledge-in-use as NSSME pointed out that the teachers at the elementary level, working in smallest schools or low-performing schools, and located in rural areas have the least resources to support their science teachers, which showed the parallel

with schools for the deaf that need to pay more attention to support wide varieties of specialized teacher groups to make science inclusive and accessible for rest of us.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

A New Path to Artificial Intelligence Proficiency: The Impact of CTCA

Racheal Fredrick*, Lagos State University, Nigeria
Esther Peter, Lagos State University, Nigeria
Peter Okebukola, Lagos State University, Nigeria
Juma Shabani, Universite du Burundi, Burundi

ABSTRACT

This article delves into the transformative potential of culturo-techno-contextual approach (CTCA) in overcoming barriers to students' acquisition of artificial intelligence (AI) knowledge. In an era where AI's significance is undeniable, the complexities of its concepts often hinder effective learning. The study adopted an explanatory sequential mixed method whereby quantitative and qualitative data were gathered. The experimental class had 15 subjects (5 males, 10 females) while the control group also had 15 subjects (7 males, 8 females) of junior secondary school 2 computer studies students (the equivalent of 8th grade). Quantitative data were collected through the artificial intelligence achievement test and students' attitude towards artificial intelligence with a respectable reliability coefficient of 0.71 and 0.61 respectively. Students in the experimental group were taught artificial intelligence using CTCA. The control class had the same learning experience as the experimental class-exclusive of the elements of CTCA. Analysis of covariance results showed that there is a statistically significant difference in the achievement of students taught artificial intelligence using CTCA and lecture method, $F(1,27) = 1.52$; $p < .05$. Within the scope and limitations of the study, it was recommended that CTCA should be adopted by secondary schools computer studies teachers in teaching artificial intelligence.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Impact of Qualitative and Quantitative Characteristics of Students' Solutions when Problem-Solving with Productive Failure

Julia Hiniborch*, Leibniz University Hannover, Germany
Gunnar Friege, Leibniz University Hannover, Germany
Jakob Hoffmann, Leibniz University Hannover, Germany

ABSTRACT

Productive Failure seems to support conceptual knowledge acquisition when teaching mathematics. Nonetheless, some studies on Productive Failure when teaching physics or teaching mathematics do not demonstrate these learning benefits. To enhance our comprehension of the contribution of students' solutions, we developed a category system to evaluate the quality and the quantity of their used methods and facts. The results indicate that the quality and quantity pattern of the students' solutions is consistent with what can be found in the literature. Correlations with conceptual knowledge indicate that neither the

quality nor the quantity of the solutions is generally related to conceptual knowledge. Only the establishing of one's own formula shows a highly significant effect. Other techniques such as using diagrams, tables or formulas do not appear to affect conceptual knowledge. This suggests that data interpretation is potentially more significant than data visualization with various representations.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Secondary Science Teachers' pPCK of the Science and Engineering Practices and Their Implementation

Harleen Singh*, California State University Stanislaus, USA
Yuxi Huang, University of Georgia, USA
Hong Tran, University of Georgia, USA
Julie Luft, University of Georgia, USA
Brooke Whitworth, Clemson Universiy, USA

ABSTRACT

This mixed-methods study attempts to explore the personal pedagogical content knowledge (pPCK) of three science and engineering practices (SEPs) possessed by secondary science teachers and their implementation in the classroom. pPCK are the personalized knowledge and skills that they draw upon to enact their instruction. The study investigates (i) teachers' pPCK of SEPs of creating and using models, analyzing and interpreting data, and engaging in argument from evidence (ii) how pPCK differed in teachers teaching in-field and out-of-field (iii) if a high level of pPCK of SEPs ensures their enactment during instruction. Participants of this study are fifteen secondary science teachers in one state in the Southeast United States. Classroom-based weekly-overview interviews and video-based interviews were used as data sources. Each round of weekly-overview interviews focused on one week of instruction, resulting in 30 instructional days over two years. For the video-based interviews, three video clips were shown to teachers and asked if they saw something important to the teaching of science, and to explain their reasoning. The video-based interviews were coded for the pPCK of teachers using a rubric developed to determine the level of student engagement with the SEPs. Analysis of the data is discussed.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Pedagogical Content Knowledge of Scientific Online Reasoning: An Exploratory Case Study

Daniel Pimentel*, University of Alabama, USA

ABSTRACT

Teaching students to evaluate the credibility of scientific claims on the internet can be challenging. This case study conceptualizes pedagogical content knowledge of scientific online reasoning (PCK of SOR) and illustrates how one high school biology teacher developed PCK of SOR by co-planning, co-teaching, and reflecting on SOR lessons. Drawing on transcripts and observational notes from lesson planning sessions and reflection interviews, the findings from this study illustrate how a focal teacher: 1) adapted instructional scaffolds to support students' scientific online reasoning, 2) employed technologies to monitor and assess students' scientific online reasoning, and 3) introduced and incorporated scientific online reasoning throughout the curriculum. The results of this study illustrate the types of knowledge and skills teachers can develop to support students in developing scientific online reasoning and science media literacy.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Exploring Secondary Science Educators' Knowledge and Experiences with Place-Based Education

Jake Johnson*, University of Nevada, Las Vegas, USA
Merryn Cole*, University of Nevada, Las Vegas, USA

ABSTRACT

Within science education, it is essential for students to connect their knowledge to real world phenomena. This study aimed to understand secondary science educators' definitions of place-based education, and explore the ways in which educators are utilizing local phenomena in their instructional practices. A digital survey was distributed to secondary science educators currently working in the classroom. The results were qualitatively analyzed, revealing definitions of place-based education involving general and local areas, with local phenomena appearing across most disciplines. Additional insights into place-based education's connections to community needs and culture were explored.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

Toward a Theoretical Framework for Data Fluency Teaching and Learning in Middle School STEM

Nicole Wong*, WestEd, USA
Rasha Elsayed, WestEd, USA
Leticia Perez*, WestEd, USA
Kirsten Daehler*, WestEd, USA
Pai-rou Chen, WestEd, USA

ABSTRACT

This paper presents findings from a qualitative study of eleven experienced STEM educators who worked alongside developers to design and implement data-rich lessons in their grades 6–9 mathematics and science classrooms. In the context of a project that seeks to develop professional learning for data fluency, researchers documented the co-development process to articulate a model of what teachers need to know and be able to do in order to support their students' data fluency. The project team distilled key findings into two framing documents: 1) a description of high-leverage areas of focus for PL and 2) a logic model that describes how the PL course under development is expected to influence teacher, classroom, and student outcomes. This paper contributes to the larger education community by defining the professional learning needs of educators who wish to integrate data into their STEM classrooms. These frameworks provide designers and researchers with touchpoints to

structure and study PL experiences, lesson materials, and other classroom resources for both new and veteran educators. These tools can provide STEM teachers with guidance for reflecting on their current knowledge, skills, beliefs, and teaching practices that help their students become more data fluent.

Strand 5: College Science Teaching and Learning (Grades 13-20)

Wicked Problems and Wicked Solutions: Graduate Students' Experiences in A Convergent Research Environment

M. Gail Jones*, NCSU, USA
Julianna Nieuwsma, NCSU, USA
Kathleen Bordewieck, NCSU, USA
Gina Childers, NCSU, USA
Steve McDonald, NCSU, USA
Anna Marshall, University of Illinois, USA
Christine Hendren, App State University, USA
Brooke Mayer, Marquette, USA
John Classen, NCSU, USA
Maude Cuchiara, NCSU, USA

ABSTRACT

Scientists are increasingly being challenged to address complex, "wicked," societal problems. This study explored graduate students' perceptions of their convergence science graduate program using a survey and social network analysis. Treatment students (engaged in convergence science) were compared to control students (engaged in traditional graduate programs). Results showed a decrease in the perception of the value of graduate work for the treatment group but not the control group. Female treatment students reported higher feelings of imposterism compared to males. The social network analysis showed the networks of research contacts increased as students worked across disciplines. The findings argue for providing students with increased support for transdisciplinary graduate research.

Strand 5: College Science Teaching and Learning (Grades 13-20)

Effect of Nature Journaling on Engagement of Non-traditional Adult Learners in a Science Methods Course

Meenakshi Sharma*, Mercer University, USA

ABSTRACT

This study examines the effect of nature journaling on engagement patterns among non-traditional adult learners enrolled in an elementary science methods course. The research aims to bridge a gap in the existing literature by investigating the effectiveness of nature journaling in enhancing learning experiences for this specific demographic. Leveraging the principles of Andragogy (Knowles, 1980), the science methods course integrated nature journaling to align with the characteristics and needs of adult learners. Through the analysis of journal entries and written reflections spanning six weeks, the study qualitatively examined behavioral, emotional, cognitive, and agentic engagement dimensions using the framework by Reeve and Tseng (2011). Results demonstrated the empowerment and

engagement of non-traditional adult learners across all dimensions, providing them with choice, flexibility, and links to personal experiences and experiential learning. The study highlights the agentic role of adult learners as they creatively applied nature journaling techniques in their classrooms, bridging the gap between theory and practice. Study findings hold practical implications for science teacher educators, offering insights to design curricula and pedagogies that resonate with the needs of non-traditional learners. Furthermore, the study aims to initiate a conversation about inclusivity and supporting non-traditional learners within science teacher education through responsive coursework.

Strand 6: Science Learning in Informal Contexts

Individuals with Autism, Virtual Reality, and Learning Environments: Inclusivity or a Medical Model of Intervention?

Darby Drageset*, University of Florida, USA
Kent Crippen, University of Flordia, USA

ABSTRACT

Non-formal science learning environments, such as museums or aquaria, can present challenges to individuals with autism spectrum disorder (ASD). These challenges can include things such as bright lights, loud noises, and unfamiliar social situations. Individuals with ASD who visit these institutions and learn in these spaces need accommodations that go beyond the standard ADA (Americans with Disabilities Act) standards for physical accessibility. Current definitions for inclusivity, including perception of the space, cognitive engagement with materials and exhibits, and social interaction, serve as a more appropriate goal. This systematic review sought to ascertain the progress of the field since Parsons' call to action in 2016 and to add needed depth to the assertions. Findings reveal a nominal amount of research investigating the potential of VR to support science learning in non-formal environments for people with ASD, a significant lost opportunity. Results further indicate that a medical model of intervention that emphasizes the social deficits of individuals with ASD is pervasive, revealing opportunities for future implementations in non-formal, science-focused environments that are participant-centered, asset-based, and innovative.

Strand 6: Science Learning in Informal Contexts

Museum Facilitator Understanding of Exhibit Potential for Open-Ended andInteractive Facilitation Encounters

Alexandria Muller*, University of California, Santa Barbara, USA
Ron Skinner, MOXI, The Wolf Museum of Exploration + Innovation, USA
Danielle Harlow, University of California, Santa Barbara, USA

ABSTRACT

In science museums, exhibits often take the form of open-ended experiences, encouraging visitors to explore scientific concepts independently. These exhibits offer multiple affordances for visitor learning, but the visitors' experience with the exhibits can rely heavily on facilitators who support visitor interactions. To foster visitor-centered experiences, facilitators must first be able to recognize the range of potential learning opportunities in a given exhibit. This research explores how museum facilitators make sense of the range of

interaction opportunities that exhibits provide. The research question guiding this work is: What characteristics of an exhibit do facilitators consider when determining the range of possible types of engagement at an exhibit? Participants addressed in some capacity all aspects of engaging exhibit design identified by Borun and Dritsas (1997) except for the readability of the exhibit. The top two exhibit design characteristics participants discussed were multi-modal and multi-outcome. Participants also grappled with a semantic challenge around interaction versus engagement that has implications for professional development. By shedding light on the practices of museum facilitators in making sense of exhibit design, this study seeks to advance the field of informal science education and contribute to the ongoing dialogue on promoting inclusivity and engagement in museum settings.

Strand 6: Science Learning in Informal Contexts

Fostering a Sense of Belonging in a Research Immersion Program

Summer Jasper*, St. Jude Children's Research Hospital, USA
Robyn Pannella, St. Jude Children's Research Hospital, USA
Katherine Ayers, St. Jude Children's Research Hospital, USA

ABSTRACT

Prior research has suggested that when people of different racial, ethnic, and national backgrounds feel a sense of community with others of similar backgrounds, it creates a greater sense of belonging (Wright-Mair, 2020). To increase access to authentic science experiences, a research hospital located in an urban city developed a research immersion program to better support students, especially those of diverse backgrounds, to pursue a career in STEM. The program used Barton & Tan's (2020) rightful presence framework to build meaningful mentor-mentee relationships and to develop a sense of belonging in STEM among students as they engaged in authentic scientific research. Working in pairs, 32 students worked alongside 16 scientist mentors for 8 weeks in a variety of laboratories, while also participating in weekly workshops. At the end of the program, a retrospective, post-program survey was given to students and mentors. This study analyzes the student's post-program survey data to determine if students felt a sense of belonging during the program by focusing on data responses related to belonging and mentorship. The study determines that students felt a sense of belonging during the program while engaging with their mentor in authentic, scientific practices to conduct research.

Strand 6: Science Learning in Informal Contexts

Cultivating Community and Identity with Latino STEM Undergraduates: Facilitating Science Learning in Family Gardens

Samuel Severance*, Northern Arizona University, USA
Alex Zazueta, University of California, Santa Cruz, USA
Isabella Rubalcava, University of California, Santa Cruz, USA
Samantha Salguera, University of California, Santa Cruz, USA
Alexie Leauthaud, University of California, Santa Cruz, USA

ABSTRACT
This case study explores how Latino STEM undergraduates' facilitation of STEM learning experiences with Latino children and their families may affect undergraduates' own STEM navigation. Seeking to attend to the ongoing challenge of underrepresentation of Latinos in STEM in the United States, this study follows the implementation of an intervention program, Semillas para Ciencia ("Seeds for Science"). University faculty organized the program as a space for Latino STEM undergraduates to connect with one another while they take the lead on engaging local Latino families and their children in using science and engineering practices within the context of each family's garden. A total of 13 Latino undergraduates participated in the program for one year, meeting regularly with one another and with faculty mentors to discuss their work with families and their STEM studies and career aspirations. Data included two online surveys, individual reflections on enacting science activities with families, and a focus group interview. Findings indicate (1) Activities allowed undergraduates to cultivate a sense of community that countered challenges to their participation in STEM, and (2) New relationships undergraduates formed with mentors and families provided opportunities for undergraduates to develop an empowered sense of STEM identity.

Strand 7: Pre-service Science Teacher Education

Representations, Decompositions, and Approximations: Improving PSETs Lesson Development through Pedagogies for Teaching Practice

David Owens*, University of Montana, USA
Kimberly Kirstein, Georgia Southern University, USA

ABSTRACT
Although pre-service elementary teachers (PSETs) face multiple obstacles, such as lack of preparation in science content, teacher preparation focused on PSETs' assets, such as their fluency with language arts (e.g., reading and writing), have the potential to contribute to their science teaching self-efficacy. In this exploratory, mixed methods study, we investigated how an assignment to develop question investigation products (Q.Is) that incorporated their strengths and interest in children's literature, contributed to PSETs' ability to plan standards-aligned learning experiences and their science teaching self-efficacy. Participants were 24 PSETs from one of two integrated physical science content courses for PSETs. We found that PSETs generally improved from the beginning to the end of the semesters in their design of QIs that provide rigorous and challenging learning experiences aligned to the standards. We consider the extent to which PSETs perceived designing QIs as an authentic approximation of teaching practice, and the role this played in fostering their self-efficacy. Some aspects (e.g., collaborating with others and peer-teaching) were identified by PSETs as contributing to enhanced self-efficacy while other aspects (e.g., evaluating peers, not having the opportunity to teach) were perceived as having detracted from their experience.

Strand 7: Pre-service Science Teacher Education

Exploration of the Use of Teacher Time-Outs to Develop Reflection-In-Action in Preservice Science Teacher Education

Laura Chalfant*, North Carolina State University, USA

Matt Reynolds, North Carolina State Unviersity, USA
Soonhye Park, North Carolina State University, USA

ABSTRACT
The study aims to understand how preservice teachers (PSTs) and science teacher educators utilize reflection-in-action through the time-out protocol and examine the impact of the protocol on PSTs' microteaching experience. This paper seeks to understand how time-outs, or allowing PSTs to stop during a microteaching lesson, to reflect-in-action can enhance their learning and understanding of pedagogical concepts. Students' microteaching lessons were analyzed for use of the time-out protocol, and selected students were interviewed to ascertain their perceptions of the intervention on their microteaching experience. The findings indicate that the time-out protocol facilitates discussions about lesson modifications, student misconceptions, and pedagogical choices, leading to a deeper understanding of teaching practice. The findings contribute to the limited research on time-outs in science education and highlight the potential benefits of integrating this approach into teacher preparation programs. This research is valuable to science teacher educators because time-outs could be a useful tool to strengthen the pedagogical content knowledge (PCK) of preservice science teachers and enhance preservice teacher education by externalizing pedagogical decision-making and promoting reflection-in-action. Science education researchers will benefit from this research because, while somewhat explored in the mathematics education literature, research on time-outs is not widely represented in science education.

Strand 7: Pre-service Science Teacher Education

Eliciting Preservice Teachers' Content Knowledge for Teaching the Small Particle Model Using Practice-Based Measures

Deborah Hanuscin*, Western Washington University, USA
Emily Borda, Western Washington University, USA
Josie Melton*, Western Washington University, USA
Jamie Mikeska*, ETS, USA

ABSTRACT
While there is a robust empirical base highlighting student difficulties and possible learning progressions for matter there is little research-based guidance for how teachers can engage elementary students in developing understanding of the small particle model of matter (SPM) as specified in science education standards. In this study, content knowledge for teaching (CKT) provides a framework for understanding the content knowledge used by preservice elementary teachers as they anticipate student ideas about the SPM. Using practice-based measures to elicit preservice teachers' CKT, we are able to recognize the strengths and assets that they leverage as they engage in the work of teaching science.

Strand 8: In-service Science Teacher Education

Heat and the City: An Experiential Learning Approach to Climate Education

Eirini Chatzara, National and Kapodistrian University of Athens, Greece
Apostolia Galani*, National and Kapodistrian University of Athens, Greece

George Arhonditsis, University of Toronto Scarborough, Canada

ABSTRACT
The global climate crisis, a most urgent issue of our time, has far-reaching implications not only for the environment, but also for society, and economies worldwide. As the world is starting to feel the multifaceted impacts of climate change, the role of education in fostering climate literacy and promoting sustainable practices has never been more critical. Climate education not only equips learners with the knowledge and skills to navigate a climate-altered society but also empowers them to participate actively in the global discourse on climate. However, achieving comprehensive climate education is no small feat. It demands a multidisciplinary approach that transcends traditional academic boundaries, including fields as diverse as social sciences, engineering, economics, and education itself. This proposal explores an experiential learning intervention designed to address these challenges and foster a deeper understanding of urban heatwaves in the context of climate change.

Strand 8: In-service Science Teacher Education

Science-Specific Teaching Challenges Among Early Career Science Teachers

Lisa Borgerding*, Kent State University, USA
Shannon Navy, Kent State University, USA
Robert Idsardi, Eastern Washington University, USA
Shane Thomas, Washington State University, USA

ABSTRACT
Science teachers in high needs districts are in high demand as a result of teacher turnover and attrition. Teacher burnout and dissatisfaction are strong predictors of this attrition. An understanding of the teaching challenges that lead to teacher burnout and job dissatisfaction is needed in order to develop resilience-promoting preservice and inservice teacher learning opportunities. This study explores the science-specific and general teaching challenges experienced by early career science teachers in high needs districts. Using a mixed methods multiple case study design, we used interviews, teaching reflections, and survey data to characterize science-specific and general teaching challenges and teachers' responses to those challenges. In terms of findings, the primary general teaching challenges included limited teacher knowledge and execution of general pedagogies such as classroom and time management, teacher management of their own emotions and burnout, and dealing with student behaviors and apathy. The primary science-specific challenges were teachers' limited knowledge and execution of instructional strategies for teaching difficult concepts, student struggles with difficult science, and insufficient or faulty science lab materials. Findings from this study can be used to better prepare and support preservice and inservice science teachers for specific challenges they face as early-career science teachers.

Strand 8: In-service Science Teacher Education

Exploring the Resilience of Early Career and Experienced Teachers Facing an Emerging Crisis

Ella Yonai*, University of Georgia, USA

Julie Luft, University of Georgia, USA
Shelley Rap, Weizmann Institute Of Science, Israel
Blonder Ron, Weizmann Institute Of Science, Israel

ABSTRACT
In this study, we explored the resilience of Chemistry teachers as they faced the challenge of teaching remotely during the Covid-19 pandemic. Resilience is a multifaceted trait developing over the course of teachers' careers that has a pivotal role in their ability to cope with adversity and change their practice. Survey data were collected online from Chemistry teachers in different stages of their careers. The data collection took place at the early stages of the transition to remote learning, capturing teachers' efforts, challenges and insights while the crisis was still emerging. Teachers' open-ended responses were analyzed utilizing the BRiTE framework that maps teacher resilience by different literature-based themes. Results highlighted differences in the resilience themes and topics discussed by experienced and early career teachers. For example in social resilience, while early career teachers were focused on redefining teacher-student relationships in remote learning, experienced teachers were building networks of professional support. Overall, experienced teachers presented a more rich and developed map of resilience that was found to contribute to their emotional well-being while teaching remotely. The implications of this study can contribute to further understanding of the resilience development continuum for teachers of all career phases.

Strand 8: In-service Science Teacher Education

Designing Elementary PD to Promote Science and Engineering Practices

Ryan Cain*, Weber State University, USA
Sara Gailey, Weber State University, USA

ABSTRACT
Our poster presents preliminary findings from a university and elementary school partnership to provide professional development (PD) for kindergarten through sixth-grade teachers. The goal of the PD was to support teachers to enact the following three science and engineering practices: developing and using models, planning, and carrying out investigations, and analyzing and interpreting data. One novel feature of the PD was having sessions dedicated to specific disciplinary core ideas with teachers from two grades that both cover the DCI. Using an existing NGSS science and engineering survey, we observed increases in survey items related to data analysis, data visualization, data analysis, and modeling, which the PD emphasized. We view these findings as evidence of the success of the nascent partnership. Since the study was conducted by early career faculty at a regional teaching institution, we believe this work will be of interest to faculty in similar contexts looking to partner with elementary schools in their communities.

Strand 10: Curriculum and Assessment

Detecting FOCIS Survey with the Partial Credit Model and Rasch Model

Xin Xia*, University of Virginia, USA

ABSTRACT

This study examined the dimensionality and effectiveness of the five categories Likert Scale of the framework for observing and categorizing instructional strategies (FOCIS), a survey that measures students' preference for learning activities in science instructions, developed by Tai et al. in 2012. The data included 6546 students from 3rd to 12th grade including 4 school districts. The results show that the FOCIS survey has 7 dimensions measuring students' preferences. This study only tests the effectiveness of the Competing dimension. Compared to the Partial Credit Model (PCM) model and Rasch model, condensing down the categories to dichotomous items fit the data better. The AIC and BIC decreased, and the infit outfit improved on the Rasch model.

Strand 10: Curriculum and Assessment

Revalidating a Measurement Instrument of Spatial Thinking Ability for Middle School and High School Students

Kannaki Thayaseelan*, University at Buffalo, USA
Yanfang Zhai, Capital Normal University, China
Xiufeng Liu, University at Buffalo, USA

ABSTRACT

Spatial thinking is a set of cognitive abilities that enable people to organize, reason about, and mentally manipulate both real and imagined spaces. One of the available measurement instruments is the Spatial Thinking Ability Test (STAT). Given the critical need for spatial thinking ability measurement and the popularity of STAT to measure spatial thinking ability, revalidation of STAT is necessary as validation of the original STAT was based on the classical test theory from which the findings are notoriously sample dependent. We used Rasch modeling to revalidate STAT as it allows parameters to be mutually independent and measures to be interval. The sample included 1340 students. Item fit statistics results and unidimensionality of the items suggested construct validity. The reliability of the instrument was moderate. The Anderson LR test indicates that the Rasch difficulty measures of STAT were not adequate for invariance. There was no DIF between two subsamples based on gender, suggesting fairness of the instrument in terms of gender. All the above results suggest that STAT possesses certain degrees of validity, reliability and fairness, and the defined construct of spatial thinking ability was reasonable, although there is still room for further improvement.

Strand 10: Curriculum and Assessment

Evaluating the Impact of NASA's STEM Programs on Student Interest, Identity, Self-Efficacy and Skills

Carla Johnson*, NC State University, USA
Janet Walton*, NC State University, USA
Toni May*, Drexel University, USA
Sera Harold*, NC State University, USA

ABSTRACT
The purpose of this study was to develop and implement an instrument for NASA which would enable the agency to evaluate middle school (grades 6-8) students' perceived outcomes of participating in NASA science, technology, engineering, and mathematics (STEM) engagement programs in the areas of interest, identity, self-efficacy, and attainment of 21st Century Skills. The research question for this study was: To what extent did validity evidence support the use of the new instrument to evaluate middle school students' perceptions of their STEM Interest, STEM Identity, STEM Self-Efficacy, and 21st Century Skills? Findings of this study included content validity, response process validity, consequential validity, and associated evidence which informed revisions to the instrument which improved it considerably. The contributions to the teaching and learning of science from this study include the fully developed tool for use in evaluating middle school students' affective outcomes from engagement in science, technology, engineering, and mathematics (STEM) programs.

Strand 10: Curriculum and Assessment

Linking Scientific and Engineering Content for the Development of Interdisciplinary STEM Projects

Janne-Marie Bothor*, University of Kassel, Germany
David-Samuel Di Fuccia, University of Kassel, Germany

ABSTRACT
Engineering content and STEM projects currently have little relevance in Germany. This is due to a lack of involvement in the education standards and the inadequate ideas of the teachers. In this university learning environment, pre-service science teachers have developed interdisciplinary projects in cooperation with engineering students, which are intended to convey both scientific and engineering content to students. The developed concepts and didactic descriptions of the projects were analyzed and the links between the interdisciplinary contents were determined. It was also investigated to what extent the contents were linked and explicitly addressed in a teaching-learning laboratory. The results show that pre-service science teachers succeed in identifying interfaces between science and engineering and linking them appropriately theoretically. In addition, however, the participants have problems concretizing the content in the teaching concepts and explicating the links between the disciplines.

Strand 11: Cultural, Social, and Gender Issues

Exploring U.S. Graduate Education through the Lens of Self-determination Theory

Karen Collier*, North Carolina State University, USA
Margaret Blanchard, North Carolina State University, USA

ABSTRACT
Graduate education holds the potential to provide educational, social, and economic opportunities. However, females, first-generation college students, and underrepresented minorities often face unique obstacles undermining their progress. The Graduate Student Success Survey II (GSSS II) was distributed to a national population of graduate students, with

a focus on underrepresented groups. Exploratory and confirmatory factor analyses were used to test the survey's validity and reliability, with 648 participants from 23 universities. A 7-factor, 40-item model was determined with the following subscales: mentor support, imposter phenomenon, financial support, microaggressions, access and opportunity (for academic writing and research), persistence, and peer support. Item analysis revealed significant differences in students' perceptions of graduate school experiences based on demographic characteristics, enrollment type, and program area. Findings lead to recommendations to enhance graduate student success.

Strand 11: Cultural, Social, and Gender Issues

K-12 Science and Mathematics Teachers' Experiences Supporting Students' Critical Consciousness: A Descriptive Systematic Review

Sheila Castro*, University of Florida, USA
Julie Brown*, University of Florida, USA
Kent Crippen, University of Florida, USA

ABSTRACT

Efforts towards providing inclusive science and mathematics education for marginalized students can be seen in increasing literature advocating for equity-oriented instruction through supporting students' critical consciousness. Despite growing literature centering teachers' development of culturally relevant pedagogies, studies examining science and math teachers supporting students' critical consciousness development are scarce. The purpose of this systematic review was to use empirical literature to explore teachers' experiences integrating sociopolitical issues (SPIs) into their science and math classrooms. Using keywords synonymous with critical consciousness, 20 studies were identified through search in various databases. The studies were analyzed through an iterative coding process which highlighted SPI topics and three components of critical consciousness: critical reflection, political efficacy, and critical application. Results of this systematic review highlight three themes in science and math teachers' practices, including 1. Teachers engaged students in the interrogation of numerous SPIs 2. Teachers and students discussed SPIs at various distances to themselves (e.g., personal, community, and global) 3. Classroom discussions and community projects were most often used to engage students in critical consciousness development. Implications include suggestions for future research and practices to improve culturally relevant science and math teaching for social justice.

Strand 11: Cultural, Social, and Gender Issues

The STEM Pipeline Metaphor: Ineffective, Dehumanizing, and Marginalizing

Christian Glandorf*, New Mexico State University, USA
Claudia Trevino, New Mexico State University, USA
H. Prentice Baptiste, New Mexico State University, USA
Paulette Vincent-Ruz, New Mexico State University, USA

ABSTRACT

The STEM pipeline metaphor is an analogy used by policymakers to examine issues with supply to the STEM workforce. In that pipeline, burgeoning scientists travel and eventually hit

"leak points" along the way in which they may opt out of pursuing a career in STEM disciplines. More recently, the pipeline has been used in context of issues of underrepresentation of marginalized social identities in STEM.
Regardless of use, the pipeline analogy is ineffective at representing the workforce issue as it compounds and validates forces of marginalization in its philosophical implications. This work demonstrates this by examining four key issues with the pipeline metaphor: the framing of the problem which the pipeline addresses, the characterization of and associated interventions at pivot points along the pipeline, the many pathways that individuals can take to STEM, and issues of people, humanization and marginalization.

Strand 11: Cultural, Social, and Gender Issues

A Look at the Spectrum of Physics Teacher Identity Among Physics Instructors

Maya Patel*, Michigan State University, USA
Maria Horak, Michigan State University, USA
Clausell Mathis, Michigan State University, USA
Delwrick Nanthou, University of Washington-Bothell, USA

ABSTRACT

Physics teacher identity constitutes an essential facet underpinning the efficacy of physics education, profoundly influencing instructors' convictions, methodologies, and engagements within the classroom. In an effort to understand the nuances of physics teacher identity, this qualitative study engaged in dialogues with ten secondary physics teachers, identifying identity markers within four domains: namely, conceptions of self, others, knowledge, and pedagogy. Through deductive analysis, we used a physics teacher identity toward equitable instruction analytical framework tailored to expound upon elements of teacher identity that align with equitable instructional paradigms. The findings showed a hierarchy across the four domains. Notably, the foremost identity markers were conceptions of self, closely succeeded by conceptions of pedagogy, others, and knowledge. The implications from the findings show significance, particularly for educators invested in the professional growth of instructors who pursue an interest in fostering equitable instructional practices.

Strand 11: Cultural, Social, and Gender Issues

Examining The Experiences of Students from Underrepresented Populations in STEM Through a Decolonized Pathway Model

Jessica McClain*, Indiana University, USA
Gayle Buck, Indiana University, USA

ABSTRACT

The performance gap of underrepresented students can be linked to a diversity representation shortage in STEM education across university and college institutional systems (Frye et al., 2021). Issues of exclusion that include a lack of roles models and deficient development of discipline-specific skills that can lead to a weed out of marginalized students in STEM courses (Dasgupta & Stout, 2014; Leslie et al., 2015; McCoy et al., 2017; Ramsey et al., 2013). As these factors mentioned above are multifaceted and diverse, educational research must consider opportunities to address these issues to improve the participation and

retention of students in postsecondary STEM courses. Scholars situate the need for programming and resources that foster an inclusive environment that aids in retention and persistence in STEM courses for marginalized students (Atkins et al., 2020; Morton & Parsons, 2018; Ortiz et al., 2020; Starr et al., 2020). Therefore, the purpose of this conceptual framework is to highlight the nuances associated with culturally centered instruction for students from underrepresented populations. In addition this conceptual frameworks hopes to commemorate knowledge of those overlooked in academic spaces as resources for students and shift conversations on retention and participation of students in STEM learning environments.

Strand 11: Cultural, Social, and Gender Issues

All of Us Working Together: Examining Bidirectional Critical Relationality in a Community-Based Informal STEM Program

Ti'Era Worsley*, The University of North Carolina at Greensboro, USA

ABSTRACT

This proposal seeks to investigate the nature of critical relationality anchored in the Black Love framework, between, a Black informal STEM educator (ISE), and Black youth through STEM-related interests and validation. Black participants in STEM spaces are typically surrounded by whiteness, not being able to bring all our intersecting identities. I explore the following research questions; 1) How does the Black Love framework support the bidirectionality of critical relationality between Black youth and the Black ISE? 2) How might bidirectional critical relationality inform Black familial capital in STEM educational threads supportive of Black youth? I frame my work using Black Love to conceptualize the fostering, restoring, and humanizing of Black youth within STEM spaces. Since this study is informed by critical relationality and disruption of power dynamics author employs participatory design research. The context is a community-based informal STEM program housed in a local Boys and Girls Club. I posit that bidirectional critical relationality be considered as a significant tool and resource for solidifying STEM-related onto-epistemologies of Black ISE and Black youth. This offers a new perspective on how ISE not only support and build sustainable communities for youth, but how youth support and provide sustainable community for ISE.

Strand 12: Technology for Teaching, Learning, and Research

Science Education and Emerging STEM Careers: The Case of Underwater ROV Operators

Minji Yun, University of Florida, USA
Kent Crippen*, University of Florida, USA

ABSTRACT

This case study of an emerging and rapidly growing STEM career will inform science educators, educational program designers, workforce development professionals, and science education researchers of the unique work systems of underwater ROV operation. This job analysis study is part of a concerted effort to broaden participation in a science career field that values skills and ways of knowing that are consistent with video game play. A systematic review of 275 job postings on LinkedIn over two months was analyzed by parallel convergent mixed methods. Topic modeling, an unsupervised machine learning technique,

indicated 10 distinct topics, which were then named and described as work systems through the results of qualitative content analysis. Nearly 20% of the job postings are represented by the top work system and 57% by the top four, suggesting a constrained career field. However, the relationships among the different industries, levels of seniority, education requirements, and KSAOs, suggest career pathways. Potential barriers to inclusion include the nature of the industries, work location, and educational and technical requirements. As part of the backward design process, this study directly affords policy-making, program development, and further research.

Strand 12: Technology for Teaching, Learning, and Research

Evaluation of Machine Learning Generated Feedback for Concept Maps

Tom Bleckmann*, Leibniz University Hannover, Germany
Gunnar Friege, Leibniz University Hannover, Germany

ABSTRACT
An automated feedback system can take a lot of the work out of the teacher's hands in the form of evaluation and analysis, and support them in their day-to-day work in the school. In most cases, however, a teacher will be able to provide higher quality feedback than an automated feedback model. Especially for formative assessment, transparent and clearly understandable feedback is a necessary criterion. The aim of this work is therefore to investigate the quality of feedback generated by machine learning. For this purpose, students' concept maps were collected and the performance of two feedback approaches was analyzed regarding quality aspects. The results show that for both approaches, a machine learning model could be developed that has a satisfactory quality. Therefore, both models will be used in schools in the near future to see how they perform in normal school life.

Strand 12: Technology for Teaching, Learning, and Research

Core Concepts of Artificial Intelligence in Education Using Robots (AIEDuRo): A Delphi Study

Divya Baranwal*, Southern Methodist University, USA
Ming Liu, National Dong Hwa University, Taiwan
Richard Duschl, Southern Methodist University, USA

ABSTRACT
This study identified core concepts to introduce artificial intelligence in education using robotics (AIEDuRo) at the secondary level. Research indicates that teaching AI and robotics concepts in the school curriculum is a crucial strategic initiative to educate the current and next generations across the globe. This research identified the goals, content, teaching-learning, methods, assessment, and effective classroom management of AIEDuRo. This study used a panel of ten computer science and teacher educators from Taiwan. A three-iterative round of Delphi was used to gather the experts' consensus on the questionnaire (sixty-six items). The 7-point Likert Scale and pre-determined criteria were set for the items. This study identifies the top five essential components in each domain of AIEDuRo. This study lays the groundwork for future empirical research on how teachers execute these concepts, navigate

intervening curriculum policies, and develop curricula to address learners' needs. This study concludes with limitations and future recommendations for research.

Strand 12: Technology for Teaching, Learning, and Research

Using ArcGIS Online in an Environmental High School Science Classroom

Jonah Firestone*, Washington State University, USA
Danielle Malone, Washington State University, USA
Sarah Newcomer, Washington State University, USA
Judith Morrison, Washington State University, USA
Lindsay Lightner, Washington State University, USA

ABSTRACT

This paper describes the integration of GIS technology in a high school environmental science classroom. The objective is to examine the impact of GIS technology on student engagement, critical thinking, and interdisciplinary learning for Education for Sustainability (EfS). ArcGIS Online and StoryMaps facilitate hands-on learning, enabling students to explore spatial relationships, analyze data, and effectively communicate insights, fostering engagement and critical thinking. GIS technology promotes interdisciplinary learning by connecting environmental science with geography and related disciplines. Students deepen their understanding of human-environment interactions by interpreting spatial data, empowering them to propose sustainable solutions to environmental challenges. Using ArcGIS Online and StoryMaps, students engaged in guided lessons, exploring sustainability topics, and creating their own StoryMaps based on a chosen Sustainable Development Goal (SDG). The findings highlight positive engagement, critical thinking, and interdisciplinary learning impacts. Students exhibited increased interest, understanding of complex issues, and developed analytical skills through spatial data analysis. The approach encouraged interdisciplinary thinking and expanded awareness of environmental challenges. Integrating ArcGIS and StoryMaps in high school environmental science promotes engagement, critical thinking, and interdisciplinary learning, supporting EfS goals. This paper underscores the importance of equipping students with skills for sustainable problem-solving.

Strand 12: Technology for Teaching, Learning, and Research

Developing Digital Education Readiness in Tertiary Education: The STEM Digitalis project

Argyris Nipyrakis*, University of Groningen, Netherlands
Lucy Avraamidou, University of Groningen, Netherlands
Gunnar Friege, Leibniz University Hannover, Germany
Eilish McLoughlin, Dublin City University, Ireland
Priit Reiska, Tallinn University, Estonia
Dimitris Stavrou, University of Crete, Greece

ABSTRACT

The integration of technological tools and informed pedagogies of effectively using technology is a continuous goal that has been highly prioritised during the recent pandemic. The STEM Digitalis project is a partnership of 5 institutions from 5 EU countries that aimed to develop digital educational resources and blended learning pedagogies in real-world

contemporary topics. Mixed methods analysis of the data gathered from the implementation of the digital scenarios provided insights concerning pre-service teachers' views on technology, engineering practices and feelings while using the digital technologies for science instruction. Overall, teachers found the technologies used as engaging and useful, and they liked the use of real data and authentic engineering practices and software. However, they highvalued the face-to-face interaction of the in-person sessions, while it was also considered important that some aspects such as interdisciplinarity and societal relevance should be made more explicit.

Strand 12: Technology for Teaching, Learning, and Research

Problem Solving in Physics – Process Data from Eyetracking-Research

Gunnar Friege*, Leibniz University Hannover, Germany
Alexander Machleid, Leibniz University Hannover, Germany
Sonja Kohlmeier, Leibniz University Hannover, Germany
Tom Bleckmann, Leibniz University Hannover, Germany
André Meyer, Leibniz University Hannover, Germany
Dirk Brockmann-Behnsen, Leibniz University Hannover, Germany

ABSTRACT

The ability to solve problems is undeniably an important part of a STEM education and is also significant beyond this. Accordingly problem solving is an active research field that is (re)growing in recent years. The focus of our studies is the investigation of problem-solving processes in physics with the method of eye-tracking. The use of this method in science education is still rare with increasing prevalence in recent years. Eye tracking is considered to have a high potential for physics education research.

Two studies demonstrate the potential of this method for problem-solving research: Study 1 is about troubleshooting in electrical circuits. Here, expert novice differences are revealed in the rarely researched area of vocational training for electricians. Study 2 analyses students' problem-solving approaches while solving a resistance network and specifically examines how students use knowledge provided in the form of a glossary. The results suggest that the concept of electrical potential in problem solving and in school and university education is neglected.

Strand 12: Technology for Teaching, Learning, and Research

Lesson Plan to Use ChatGPT in Science Teaching: Lessons from Pre-Service Teachers' Perspectives

Gyeong-Geon Lee*, University of Georgia, USA
Xiaoming Zhai, University of Georgia, USA

ABSTRACT

This study explores the integration of ChatGPT, a large language model (LLM), into science education, focusing on the perspectives of pre-service teachers. Traditional teaching methods have been challenged by the rise of artificial intelligence (AI) and machine learning (ML), with ChatGPT emerging as a promising tool for educational practice. Despite the buzz around ChatGPT's potential, empirical studies exploring its actual utility in the classroom remain scarce. This study aims to fill this gap by analyzing the lesson plans of 29 pre-service elementary teachers from a Korean university to assess how they envision incorporating ChatGPT into science classrooms. The results show diverse applications in different science domains, with biology being the most popular. The study also identifies both innovative and undesirable use cases of ChatGPT in lesson plans. On average, the lesson plans scored well on a modified TPACK-based rubric, indicating a reasonable understanding of how to integrate ChatGPT into the classroom. Pre-service teachers anticipate that ChatGPT will enhance student engagement and individualized learning, but also express concerns about its accuracy and potential over-reliance. The study underscores the need for further research on the role of AI in actual classroom settings and provides insights for future AI-integrated teaching practices.

Strand 13: History, Philosophy, Sociology, and Nature of Science

On Problematizing the Epistemic and Axiological Nexus of Post-Normal Science Education

Hendra Agustian*, Department of Science Education, University of Copenhagen, Denmark

ABSTRACT

In this paper, I adopt the notion of "post-normal science" from philosophy and sociology of science to frame an analysis of highly complex socio-scientific issues. Subsequently, I will characterize and problematize research development in epistemic science education. With higher science education in mind, I will propose some recommendations to advance research in this area.

Strand 13: History, Philosophy, Sociology, and Nature of Science

Comparing Chemists' Views of the Nature of Science (NOS) With Their Levels of Research Expertise

Tulana Ariyaratne*, University of Cincinnati, USA
Valarie Akerson, Indiana University, USA
Cathrine Reck, Indiana University, USA

ABSTRACT

The Nature of Science (NOS) is a critical component of scientific literacy that enhances science learners’ understanding and helps them make informed decisions. Even though NOS was considered a structural facet of scientific literacy not much research has been conducted on the ideas of scientists. This study investigated the views of nature of science (NOS) of 40 participants in chemistry who have or had exposure to chemistry research in one chemistry department in a large R-1 university in Midwest. The participants' chemistry research exposure varies from no research to 31 years of research exposure. Undergraduates (junior and senior), graduate students, postgraduate researchers, faculty and scientists were recruited to this study to understand how their NOS understanding develops with their research exposure. The data were studied quantitatively and qualitatively. The different professionals had different and unique ideas about different NOS aspects. According to the demographic data that were collected, it was found that there were several factors that influence NOS understanding. Science content knowledge and research exposure indeed develop science learners'/researchers’ NOS understanding, but NOS understanding is not

developed proportionally to the amount of science content knowledge or research experience that an individual gained.

Strand 13: History, Philosophy, Sociology, and Nature of Science

A framework to Conceptualize Misinformation Literacy in Science Tasks

Dante Cisterna*, ETS, USA
Cheryl Lavigne, ETS, USA

ABSTRACT

Science misinformation is a growing problem that can have negative impacts on students' learning of science in topics such as global climate change, health and nutrition, and diseases. Drawing on literature from civic education, socioemotional learning, cognitive psychology, and digital literacy, we propose a framework to address misinformation literacy in science to help students develop the knowledge, skills, and dispositions aligned with (mis)information literacy. The framework is composed of six dimensions: demonstrating scientific literacy of the science topic of interest, investigating and recognizing the credibility of sources, exercising digital literacy strategies and knowledge of the Internet, understanding how scientific knowledge is validated and created, identifying how misinformation works, and engaging in awareness of epistemology. This framework can inform the development of instructional and classroom assessment tasks that address misinformation and that can be integrated into science tasks. To illustrate how a misinformation-based task can be realized, we describe the storyline of a task prototype for middle school students. The task asks students to evaluate the validity of a viral claim about food nutrition in the school context.

Strand 14: Environmental Education and Sustainability

"Wait, We Get to Build That?" Outcomes of a Co-Created, Classroom Citizen Science Project

Laura Carsten Conner*, University of Alaska, Fairbanks, USA
Nathan Kettle, University of Alaska, Fairbanks, USA
William Simpson, University of Alaska, Fairbanks, USA
Krista Heeringa, University of Alaska, Fairbanks, USA

ABSTRACT

Citizen science projects have the potential to connect learners with science by immersing them in socioscientific issues of local and personal interest. This research investigates identity-related outcomes among students participating in a co-created, classroom-based citizen science program around air quality in the far north. Using a pre/post survey, we found significant and/or marginal shifts in identity-related constructs. Analysis of open-ended responses revealed that building the air quality sensors was the aspect of the project that students found most enjoyable, and the one that most frequently made them feel like scientists. Our results imply that classroom citizen science in which students have agency in tool construction and use has potentially important consequences, especially with regards to making students feel competent in science.

Strand 14: Environmental Education and Sustainability

Learning About Climate Change – Comparison of Three Instructional Approaches

Sophia Siegmann*, Institute for Didactics of Mathematics and Physics, Physics Education Group, Germany
Gunnar Friege, Institute for Didactics of Mathematics and Physics, Physics Education Group, Germany

ABSTRACT
Climate change is one of the biggest challenges facing society, so environmental issues are a global problem. So, learners' attitudes and knowledge on the subject play an important role for future generations. Therefore, this topic should be taught in schools. This intervention study explained here investigates three instructions (direct instruction, problem-solving approach and inquiry-based learning) that have been developed and implemented in physics classes on the topic of climate change. The study compares the three instructions in learners' attitudes and knowledge. Results were collected using pretest and posttest. 460 learners from 21 classes participated in the study. Learners' attitudes show differences in pre-posttest. Only minor differences are found in the comparison of the instructions. The physical knowledge about climate change is investigated by student perceptions and shows significant differences when comparing the instructions. Overall, the study is not only interesting from a research perspective, but the lessons developed support teachers in their work. The integration of the topic of climate change into the given lesson content can thus be simplified. A further development of the lessons is planned and will be implemented with a follow-up study.

SeeMeTeach
Sponsored Session
Teacher Observation Reimagined – Using the SeeMeTeach Observation App
19-Mar-24, 4:15 PM-5:00 PM
Location: Governor's Square 10

Teacher Observation Reimagined – Using the SeeMeTeach Observation App

ORGANIZER
Craig Berg, SeeMeTeach, USA

ABSTRACT
SeeMeTeach is a teacher and classroom observation tool designed to collect qualitative and quantitative data on teacher actions and student engagement with instant analysis for feedback and coaching sessions or research or grant evaluation. The quantitative mode is unique and powerful, allowing the single observer, or a team of observers, to collect an immense amount of critical data on teacher performance and student actions, helping researchers or observers determine the growth in teaching or the impact of professional development on teaching and classroom instruction. Participants will get a free account and learn how to use this new online app at no cost.

Community Training and Assistance Center (CTAC)
Sponsored Session
Integrated PreK-12 STEM as a District-Wide Equity Move
19-Mar-24, 4:15 PM-5:00 PM
Location: Governor's Square 11

Integrated PreK-12 STEM as a District-Wide Equity Move

ORGANIZER
Scott Reynolds, Community Training and Assistance Center (CTAC), USA

ABSTRACT
While the demand for STEM professionals continues to grow, students are being shut out of STEM—with a lack of instructional time devoted to students in lower grades, and STEM coursework enrollment in upper grades underrepresenting girls, students of color, and low-income students. This must change and is exactly what PreK12-STEM has accomplished in one California school district. This session focuses on a study conducted as a part of the U.S. Department of Education's Education Innovation and Research (EIR) program. The intervention under study consists of three key components: 1) developing and delivering integrated STEM curricula as a part of the core curriculum for all students PreK-12 2) engaging internal and external partners 3) providing school sites with professional learning supports. Participants will learn what students experience in each of the 52 integrated STEM units, what partners were engaged, and the extent of supports provided to school sites and their leaders. Come learn from this five-year project and see if districts you work with might be interesting in opening these STEM doors for students.

JRST
Social Event
JRST Editors' Dinner
19-Mar-24, 5:15 PM-6:45 PM
Location: Governor's Square 16

JRST Editors' Dinner

Research Committee
Sponsored Session
Sandra K. Abell Institute for Doctoral Students Poster Symposium
19-Mar-24, 5:15 PM-6:45 PM
Location: Governor's Square 10

Sandra K. Abell Institute for Doctoral Students Poster Symposium

ORGANIZERS
Julianne Wenner, Clemson University, USA
Amelia Gotwals, Michigan State University, USA
Christina Schwarz, Michigan State University, USA
Brooke Whitworth, Clemson University, USA

ABSTRACT
The Sandra K. Abell Institute for Doctoral Students (SKAIDS) was established to support the professional development and education of doctoral students involved in the study of science education. Over the years, SKAIDS has provided a space for doctoral students to establish a community within NARST and to build long-lasting relationships with peers and mentors. During this session, the SKAIDS Fellows from the 2023 Institute co-hosted by Clemson University and Michigan State University will present posters that highlight how their work developed over the course of the intensive week-long institute.

SKAIDS 2023 Mentors:
Amelia Gotwals, Michigan State University
Tia Madkins, University of Texas-Austin
Sonya Martin, Seoul National University
Regina McCurdy, Georgia Southern University
Zukiswa Nhase, University of the Free State
Meredith Park-Rogers, Indiana University-Bloomington
Christina Schwarz, Michigan State University
Julianne Wenner, Clemson University
Brooke Whitworth, Clemson University
Laura Zangori, University of Missouri

Poster Presenters:
Akgun, Selin, Michigan State University - Supporting Elementary Students in Science Sensemaking: Sensemaking Practices and its Relationship to the Developing Teacher Identity
Barres Spezza, Stephanie, University of Chicago - Disrupting Epistemic Supremacy: Latin* Students' Engagement in an Arts-Based Social Justice-Centered Classroom
Bateman, Jennifer, Clemson University - Ties Between Science Educators: A Social Network Analysis
Bernhard, Tess, University of Pennsylvania - Investigating the Digital Platforms that Shape Us: Multimodal Classroom Observation for the 1:1 Science Classroom
Conrath, Brandin, Pennsylvania State University - Teaching in Support of Geoscience Simulation-Based Curricula
Cooke, Hannah, University of Connecticut - "You Get None of That": Critical Discourse Analysis of Science Teachers' Race Talk
Cotta, Deborah, Universidade Federal de Minas Gerais - How Does a Bottle of Acid Become a Resource to Talk About Science in a 2nd Year Classroom

Ettenauer, Barbara, Oregon State University - Concept Maps from a Contemporary Perspective
Garner, Amanda, University of Tennessee - Data Literacy and Place-Based Learning: A Generative Synthesis of Literature and Possible Scenarios for Learning
Gil, Minyoung, Pennsylvania State University - Exploring Kindergarten Classroom Discourse on Decision-Making During Engineering Design Activities: A Case Study
Helton, Emily, University of West Virginia - Ready OER Not: Engaging Teachers with Student Identity through Open Pedagogy
Howd, Beth, Pennsylvania State University - Analysis of the changing roles of U.S. science teachers since the publication of A Nation at Risk
Jen, Tessaly, Vanderbilt University - Speculative Science Education Toward Socioecological Care
Jenkins, Austin, Purdue University - A Family Affair: Examining the Current Research on Out of School Family Engagement in Science
Killen, Heather, University of Maryland - Building Climate Change Understanding Within a Skeptical Rural Community: The Role of Local Knowledge When Expanding a Shared Evidence Base
Lee, Sarah Jaewon , Vanderbilt University - Culturally Relevant Storytelling in a Mixed-Reality Science Through Technology Enhanced Play Curriculum
Mahapatra, Swarna, University of Missouri - Identity Development of Preservice Elementary Teachers
Metcalf, Allison, Florida State University - "I Am Deeply Struggling": Exploring the Complexity of Wrestling with Expansive Conceptions of Science Teaching and Learning
Ortiz, Rita, University of South Florida -Using an Ecojustice Framework to Examine Human and Earth Interrelationships for Science Teacher Education
Pirkle Howd, Laura, Pennsylvania State University - Title TBD
Rock, Ronan, University of Illinois - A Framework for Experiencing Expansive Genders in Science Education
Schwendemann, Meredith, Clemson University - Exploring District Science Coordinators' Conceptions of Equity
Sebatana, Judicial, North-West University - Development of a Framework on Simulation-Embedded Scaffolding of Problem-Based Learning for Science Teachers' Self-Directedness
Sircar, Monica, Stanford University - Understanding Teacher Experiences of Localizing a Phenomenon-Based Climate Change Curriculum
Staggs, Molly, University of Florida - How Do Teachers Connect Multilingual Learners' Funds of Knowledge to Science Content?: An Epistemic Network Analysis
Stoeckel, Marta, University of Minnesota - Peer Recognition in High School Physics During Small Group Work
Stoler, Annabel, Boston University - Shifts in Classroom Culture Through a Progression of Modeling Activities
Syifa, Mutiara, Ohio State University - Preservice Science Teachers' Disposition Shifts Towards Culturally Sustainable Teaching Through Multidimensional Noticing for Equity
Wagner, Lauren, Florida State University - A Study of Lake Elberta: Using Community Watersheds to Design Environmental Justice Learning Experiences for Elementary Preservice Teachers

Wright, Kendra, University of Memphis - Exploring How Metacognition and Mindset Contributes to Academic Success in Undergraduate Biology Majors
Zohery, Vivian, University of Maryland - Sisters in STEM: Muslim Women Decolonizing STEM Education

---

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
Engineering, Physics, and Control-of-Variables
19-Mar-24, 5:15 PM-6:45 PM
Location: Plaza Court 6

A Method to Their Madness; Characterizing Early Elementary Children's Artifact Change During Engineering Design
Christine McGrail*, University of North Dakota, USA

ABSTRACT
Science education has begun the work of incorporating engineering design at the behest of The Framework for K-2 Science Education and the Next Generation Science Standards, yet the science education community is still developing an understanding of how elementary age students learn with an integrated science and engineering design approach. Contrary to the widely held perception that children tinker in a desultory manner, young children are primarily purposeful as they make changes to their design artifacts while engaged in engineering design challenges. The current study of 26 children aged 7-8 from across 13 U.S. states determined that children exhibit three types of interaction while constructing an artifact during an engineering design challenge, as demonstrated while constructing a cotton ball launcher. With an improved understanding of the three types of change that early elementary learners enact during engineering design, science education can further direct its efforts to support science learning using engineering design activities.

Examining Middle School Students' Epistemic Practices of Engineering During Small Group Work
Muhammad Purwanto*, University of Minnesota Twin Cities, USA
Gillian Roehrig*, University of Minnesota Twin Cities, USA
Jeann Wieselmann, Southern Methodist University, USA
Ramya Sivaraj, University of Minnesota Twin Cities, USA

ABSTRACT
K-12 students are expected to work collaboratively in small groups to develop solutions to engineering design problems mirroring the practice of professional engineers. These small group engineering design activities offer opportunities to examine how discourse shapes understandings and to analyze epistemic practices as students construct meaning as they engage in the engineering design process. However, limited research focuses on student discourse and dynamics during small-group engineering design work. Given the importance of this topic, we explored students' engagement in epistemic practices of engineering during

small-group engineering design activities. This study utilized a qualitative case study design to examine in what ways students engage in epistemic practices of engineering during small-group engineering design activities. Participants of this study were four sixth-grade boys, ages 11-12 years, at a diverse suburban middle school in the Midwest. Through analysis of small group videos, our findings showed that during an engineering design process within a STEM-integrated unit, students engaged in a wide range of epistemic practices of engineering during interactions with peers, such as applying mathematics and science knowledge, where the interactions were largely independent from teachers' facilitation or scaffolding. Findings also emphasized how individual and group cognitive processes, sense-making, and knowledge-building were inherently interwoven.

Interpreting Graded Problem Solutions: The Inconsistent Messages That Students Receive

J. Caleb Speirs*, University of North Florida, USA
Mark Swartz, University of North Florida, USA
Sarah Nguyen, University of North Florida, USA
W. Brian Lane, University of North Florida, USA

ABSTRACT

The goal of this project was to observe how physics students react to differences in instructor grading styles. Based off of previous work done by Henderson et. al., two styles were compared: an instructor who places the burden of proof on the student (student burden of proof, or S-BoP), and an instructor who places the burden of proof on themselves (instructor burden of proof, or I-BoP). To study this, we created three hypothetical student responses to a kinematics question on which we placed markings from a hypothetical instructor (either Professor Oval, the S-BoP professor, or Professor Circle, the I-BoP professor). Participants were shown the same three hypothetical students work marked by the two different instructors and were asked to fill out a questionnaire regarding the two instructors grading styles. General results from this questionnaire will be discussed. Some results show that grading practices surrounding partial credit can potentially have an negative impact on student willingness to show work or provide justification for their answers.

Learning the Control-of-Variables Strategy through Self-Generated and Vicarious Errors

Linda Haemmerle*, University of Vienna, Austria
Shelbi Kuhlmann, University of Memphis, USA
Theresa Krause-Wichmann, Saarland University, Germany
Andrea Moeller, University of Vienna, Austria

ABSTRACT

Harnessing errors as learning opportunities, this study investigates the potential of learning from self-generated and vicarious errors in the context of experimentation, which is a key scientific practice. The control-of-variables strategy (CVS) in experiments is crucial for gaining valid results; however, learners struggle to understand and successfully deploy this strategy. In this study, we investigate whether middle school students achieve higher CVS skills by engaging with self-generated or vicarious errors and if a combination yields greater improvement. Additionally, we explore potential mediating effects of learners' cognitive load,

their intrinsic motivation, and their emotions. Using the problem-solving-prior-to-instruction approach, where learners engage in problem-solving and then receive instruction, we employed a randomized 2x2-factorial design including four conditions: self-generated-errors group (EG1), vicarious-errors group (EG2), a combination group (EG3) and a no-errors group (EG4). Results reveal statistically significant differences among groups in the CVS posttest performance, in which both the self-generated errors and no errors groups outperformed the combination group. Interestingly, students who generated their own errors experienced statistically significantly higher extraneous cognitive load and negative affect; however, these processes did not significantly mediate the relationship between generating their own errors and their learning gains.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies
Related Paper Set
Citizen Science in Elementary Settings: Fostering Engaging, Authentic, and Meaningful Science Learning
19-Mar-24, 5:15 PM-6:45 PM
Location: Plaza Court 2

MothEd - Authentic Science for Elementary and Middle School Students

Peter White*, Michigan State University, USA
Brian Keas, Michigan State University, USA
David Stroupe, The University of Utah, USA

ABSTRACT
There is often little agreement about students' epistemic roles in classrooms. Here, we provided students with opportunities to take up epistemic agency during a multi-week unit about moth ecology. Students learned about moths through the co-design and enactment of research projects. We collected and analyzed data from three types of episodes: planning sessions, classroom observations, and artifacts (teacher and student-created documents). As the research team positioned students as epistemic agents, the students, the teacher, and the research team co-developed three types of tools (data collection sheets, a display board of moth samples, and a daily research plan). The co-development of the epistemic tools prompted constant negotiation of the purpose of the unit and students' epistemic roles. Initially, students were hesitant to offer ideas and to suggest tools – they were concerned that the researchers and teacher wanted "right answers" rather than to genuinely co-design research. The researchers and teacher had to legitimize students' ideas, research designs and epistemic tools. In doing so, students began to perceive that they could take up epistemic

agency. Our findings support the position that students – who are typically marginalized from epistemic agency– can co-develop epistemic tools and take on new epistemic roles in classrooms.

Supporting Elementary Teachers' Science Instruction through School-Community Partnerships to Design and Teach Locally-Relevant Citizen Science

Lara Gengarelly*, University of New Hampshire, USA
Sameer Honwad, University at Buffalo, USA
Megan Glenn, University of New Hampshire, USA
Erik Froburg, University of New Hampshire, USA
Malin Clyde, University of New Hampshire, USA
Haley Andreozzi, University of New Hampshire, USA

ABSTRACT

In the United States there is an increasing demand for teacher professional development (PD) focused on science instruction aligned with the contemporary vision put forth by Next Generation Science Standards (NGSS). This study investigates a new PD model that partners K-5 teachers with University of New Hampshire Cooperative Extension science volunteers to create a community-based partnership that improves educators' use of locally-relevant, citizen science projects. To examine the nature of the partnership, changes to teacher self-efficacy beliefs and integration of the NGSS science practices, we administered pre/post surveys and interviews and analyzed the contents of the teacher-volunteer co-designed curriculum units. The study sheds light on the affective domains that play a role while building a sustainable partnership between teachers and volunteers. Our study indicates that teachers and volunteers understand that school-community partnerships are important and beneficial to science learning. Our findings suggest that teachers' self-efficacy teaching science increased and integration of NGSS science practices in the classroom improved. The Schoolyard SITES PD model constructs a pathway for how volunteers and teachers can build a sustainable partnership so as to engage elementary students in citizen science and authentic science practices.

Engaging Elementary School Students in Community and Citizen Science to Support Socio-Ecological Systems Resilience

Shulong Yan*, University of California, Davis, USA
Alexandra Race, University of California, Davis, USA
Heidi Ballard, University of California, Davis, USA

ABSTRACT

In the face of the climate crisis, effective climate change education is essential. This study investigates a Community and Citizen Science program that employs socioecological systems (SES) framing to empower students to take collective climate action. This Community and Citizen Science (CCS) initiative involves elementary students in collecting forest data for insights into wildfire management. Using the Environmental Science Agency (ESA) framework, the study examines the development of students' socioecological knowledge and scientific skills. Results indicate that students grasp the intricate impacts of

wildfires on interconnected systems and demonstrate varying levels of proficiency in system-thinking skills. This approach to localized CCS programs has the potential to cultivate knowledge, skills, and resilience in young learners, thereby contributing to proactive climate education efforts.

Citizen Science in Elementary Classrooms: A Tale of Two Teachers

Patrick Smith*, Horizon Research, Inc., USA
Sarah Carrier, North Carolina State University, USA

ABSTRACT

When CS projects are incorporated in formal school settings, students have an opportunity to engage in real-world projects as they collect and make sense of data, yet few CS projects offer substantial guidance for teachers seeking to implement the projects, placing a heavy burden on teacher learning. Framed in theory on teacher relationships with curricula, we prepared science standards-aligned educative support curricula for two CS projects, designed to guide both teacher and student learning, Our paper describes two teachers' contrasting implementation of CS in their 5th grade classrooms using support materials for one of the two CS projects. Both are veteran teachers at high-needs rural schools in the southeast. Using observation, interview, and student focus group data, we examine teachers' interpretations and enactment of CS using educative support materials One teacher demonstrated a traditional teaching approach and limited use of the project materials. In contrast, the second teacher took up the materials enthusiastically, pushing herself and her students to excel in data collection and analysis. We will discuss implications that can inform researcher and curriculum developers' efforts to support elementary teachers' use of CS, science instruction that provide students experiences with authentic science data collection and sense-making.

Strand 5: College Science Teaching and Learning (Grades 13-20)

Related Paper Set

Shifting Perspectives: Embracing Systemic Lenses in Discipline-Based Education Research

19-Mar-24, 5:15 PM-6:45 PM

Location: Governor's Square 11

Drawing Connections Between Macro-Activity Systems and Micro-Interactions: Variation in Learning Assistant Facilitation Practices

Ira Caspari-Gnann*, Tufts University, USA
Nicolette Maggiore, Tufts University, USA
Jessica Karch, Tufts University, USA

ABSTRACT

Learning assistants (LAs) are advanced undergraduate students who facilitate student learning during interactive lectures. Research on LA implementations has shown improved

student learning outcomes, however, there are discrepancies in outcomes for different STEM courses, which may be connected to differences in implementation. Investigating how differences in LA implementation lead to different ways LAs facilitate and thus influence student learning necessitates connecting two levels of the system, i.e., the macro-classroom and the micro-LA-facilitation levels. Our research achieves this connection by triangulating two sociocultural frameworks and multiple data sources from different stakeholders (i.e., professor, LA, and student). We conducted a multiple case study with 10 classroom cases: 7 general chemistry and 3 introductory physics classes at 2 institutions. The 10 classroom cases included 5 professors, 30 LAs, and 789 participating students. Each of the 10 classes followed one of three LA facilitation patterns. For 8 classes, the professor's object (goal) most directly explained which LA facilitation pattern occurred. An explanatory account for the remaining 2 classes included a complex interplay of other components of the classroom systems. The power the professor has in setting up the classroom system and implications for reflection and training will be discussed.

Problematizing Effective Learning: What Does It Mean for a Learning Moment to Be Considered Effective?

Jessica Karch*, Tufts University, USA
Ira Caspari-Gnann, Tufts University, USA

ABSTRACT
Although the goal of active learning reform is to foster learning, little research has looked at what it actually means for learning to be considered "effective." Furthermore, defining concepts like effectiveness is often done through the researcher's analytical lens, rather than attending to students' own history, motivations, or context. To explore this, this paper invites conversation problematizing the concepts of "effectiveness" and of "learning" by interrogating a single interaction from the perspective of multiple stakeholders with different levels of power within a classroom system, including LAs, students, the professor, the researcher, and external members of the research community. To investigate this, we used multiple streams of data including the interaction video, stimulated retrospective interviews with different stakeholders, the research team's own writing and analysis, and a composite narrative based on field memos from a workshop presentation of the interaction. Using practical epistemology analysis to characterize in-the-moment learning and cultural historical activity theory to characterize the activity systems, we found that different perspectives on whether the interaction was deemed effective was mediated by stakeholders' proximity to and power within the classroom system and their epistemological beliefs. Implications for teaching and learning will be discussed.

When Boundaries become Barriers: Investigating Admission Standards for Chemistry Graduate Programs

Jocelyn Nardo*, The Ohio State University, USA

ABSTRACT
The following qualitative study addresses educational responsibility by exploring how a Midwestern university systematizes the professional development of historically marginalized graduate students within a chemistry graduate program. To do this, I draw theoretically from Anzaldúa's (1987) Borderlands theory and methodologically from Porter and colleague's (2019) institutional critique to understand how the graduate program's professional development milestones organize ways of knowing and being a chemist.

Beyond Large Enrollments: Cultivating Latine Student Success in Introductory Chemistry through Servingness-Centered Evidence-Based Pedagogies
Paulette Vincent-Ruz*, New Mexico State University, USA
MaryAnn Long, New Mexico State University, USA
Christian Glandorf, New Mexico State University, USA
Taiwo Adesunloye, New Mexico State University, USA

ABSTRACT
In response to the critical imperative of addressing underrepresentation and educational debt among Latine students in STEM fields at Hispanic-Serving Institutions (HSIs), our proposal endeavors to develop servingness-centered evidence-based pedagogies in the chemistry classroom. In the STEM classroom, the concept of "servingness" should actively facilitate and encourage the success of students beyond just cognitive outcomes. Researchers have advocated for the application of active learning practices to effectively achieve this objective. However, over the years research has shown conflicting evidence regarding: 1) Students' perceptions of learning, 2) Barriers to implementation of these strategies, and 3) Whether these strategies are truly effective in bridging educational debts. This suggests that relying solely on active learning might not be sufficient to adequately tackle the educational disparities faced by Latinx students in the STEM classroom and to nurture their ability to navigate between their Latine identity and STEM identity. The study aimed to answer whether active learning curriculum (POGIL) produce outcomes beyond cognitive? The study was carried out in a Hispanic-Serving Institution (HSI) with a 65% Latine student population. The study demonstrated that POGIL is effective to increase student's cognitive outcomes like scores and self-efficacy but does not contribute to an increased sense of belonging.

Understanding First-Generation Students' Experiences: An Asset-Based Approach
Klaudja Caushi*, Boston University, USA
Binyomin Abrams, Boston University, USA

ABSTRACT
Despite efforts to diversify STEM fields, there are persistent issues of underrepresentation of first-generation students (defined as those whose parents or legal guardians lack a baccalaureate degree) in STEM. Among systemically excluded students, first-generation students comprise at least a quarter of the undergraduate population in the United States. Studies on first-generation students have utilized a deficit-oriented approach, which focuses on the barriers inhibiting student success. While understanding the challenges faced by

these students holds significance, critical scholars argue that deficit thinking may foster the mindset that students need to conform to established norms to prosper in STEM. This perspective might lead educators and administrators to overlook the array of strengths that first-generation students inherently possess due to their distinctive cultural and life experiences. In this study we take an asset-based approach in illuminating the strengths of first-generation chemistry and biochemistry students and shedding light on the academic and non-academic support systems that contribute to their success. Data in the form of interviews and focus groups were collected and analyzed. Students identified their utilization of social, familial, navigational, and resistant capital as strategies to navigate their chemistry or biochemistry degrees. The support systems that students relied upon will be discussed.

Emergence of Embedded Activity Systems in the Chemistry Laboratory
Clarissa Keen*, Boston College, USA
Hannah Sevian, University of Massachusetts Boston, USA

ABSTRACT
Science educators often grapple with assessing student learning in collaborative environments such as the undergraduate teaching laboratory. This is in part due to the number of variables associated with students working together on a task and the situated nature of the laboratory within the broader course. This work accounts for this complexity by using sociocultural activity theory as an analytical framework to capture and compartmentalize components of the undergraduate general chemistry laboratory activity system. Data collected from first and second semester general chemistry laboratory courses were used to construct second-generation activity system triangles. Through this qualitative analysis, four levels of activity systems emerged: 1) the system of the university or students' general life/career, 2) the system of the chemistry lecture course, 3) the system of the general laboratory course, and 4) the system of the specific laboratory activity. Analysis of the interactions and contradictions between the components of these systems lead us to propose the theoretical concept of embedded activity systems that can be used to visualize the interconnected nature of multiple systems simultaneously. This conceptualization recognizes the influence of broader systems on the specific laboratory activity and illuminates important systemic variables involved in learning.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set
Effects on informal Science Learning on STEM Career Interests
19-Mar-24, 5:15 PM-6:45 PM
Location: Governor's Square 12

Virtual and Augmented Reality Enhanced Science Learning and Incorporating Socioscientific Issues in Informal Learning Environment
Sharfun Islam Nancy*, University of South Florida, USA
Dana Zeidler, University of South Florida, USA

ABSTRACT
The ubiquitous nature of technology tools has made it essential to explore its appropriate usage and benefits so that these technologies can be used properly in the classroom or in informal settings. It has also become essential to understand that learning STEM with technology also has drawbacks if it is devoid of moral and sociocultural aspects. To address these issues this study ventures into understanding the role of novel technology tools such as virtual reality, augmented reality, and robotics in students' science learning in an informal environment of a summer STEM robotics camp. We have also looked at the incorporation of socioscientific issue topics besides their STEM activities and how students adjusted their thinking in accordance with these two aspects. Results indicate that technology tools have numerous possibilities in students' STEM learning if these are appropriately utilized in accordance with the content being taught. A positive shift in students learning was found. This study has implications for future researchers and practitioners to incorporate technology tools in their informal learning environment.

Improving High School Students' Attitudes Towards Quantum Information Science and Technology in a Summer Program

Angela Kelly*, Stony Brook University, USA
Michele Darienzo, Stony Brook University, USA
Tzu-Chieh Wei, Stony Brook University, USA
Dominik Schneble, Stony Brook University, USA

ABSTRACT
The intervention for the current project, Quantum Information Science & Technology Summer Camp (QIST Camp [pseudonym]), was designed to provide opportunities for diverse groups of high school students to participate in quantum education in university and informal settings. University science education and quantum physics researchers designed and initiated a one-week, 25-hour summer program for students in grades 10-12. Workshop structure was based upon the theory of planned behavior, where QIST careers may be viewed as achievable choices if students have disciplinary knowledge, confidence they may overcome academic obstacles, expectancy of vocational roles, and goals consistent with their aspirations. A within-group pre-/post-survey with exploratory factor analysis identified four latent constructs in students' attitudes towards QIST, including (1) QIST self-efficacy, (2) QIST relevance, (3) QIST self-concept and career interest, and (4) QIST reasoning and epistemology. Paired samples t-tests indicated students improved their overall attitudes towards QIST learning, as well as their self-efficacy and knowledge of QIST relevance, with medium effect sizes. There were no changes in students' QIST self-concept and career interest and their QIST reasoning and epistemology. This informal summer program showed promise in promoting positive student attitudes towards QIST, a critical emerging field in advancing technological solutions to global challenges.

The SEMinal Impact of Out-of-School Science: A Study of Affective Models in Authentic Learning

Ella Yonai*, Weizmann institute of science, Israel
Ron Blonder, Weizmann institute of science, Israel

ABSTRACT
In this study, we explored the affect of an authentic out-of-school learning activity on student beliefs regarding their efficacy and aspirations to develop scientific careers. Moreover, we estimated the role of student emotions as possible mediators of this affect. The activity involved experiencing different authentic science skills and centered on the 'hands-on' operation of a scanning electron microscope (SEM) with scientists in a research institute. The research tools included a questionnaire with three sections: 1. Measuring the perception of authenticity (Post, 7 items, Likert scale), 2. a semantic differential emotion questionnaire (SDEQ) (Post, 11 items), and 3. Beliefs questionnaire in two parts: Self-efficacy and science aspirations (Pre-Post, 7+5 items, Likert scale). The collected data were integrated into a quantitative model with authenticity as an independent variable, the differences in the pre-post belief structures as the dependent variable and the emotions as mediators. Multiple regression analysis, including PROCESS module, evaluated relationships in the model to assess the significance of the mediation. Results indicated that perceived authenticity significantly predicts both self-efficacy and career aspiration. However, only the self-efficacy model was found to be mediated by emotions. The study makes a theoretical and practical contribution to understanding affective mechanisms underlying out-of-school science activities.

Profiling International Students in a Science Competition – Insights Regarding Science Education and Promising STEM-Careers

Charlotte Falkenberg*, Leibniz Institute for Science and Mathematics Education, Germany
Ute Harms, Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
This questionnaire study takes a holistic look at the development of STEM talents in science competitions as an extracurricular learning opportunity. The participants of the International Biology Olympiad 2023 were surveyed to identify relevant aspects of success on an individual level as well as on the level of the educational system of the country of origin. An important finding of our survey is that female participants perform significantly less successful compared to the male counterparts. Thereby they start with lower expectations of success, lower domain specific self-concept but greater fear of failure. However, at an individual level, intrinsic participation motivation and competitive goals in particular appear as predictors of success, as well as a high need for cognition and, in tendency, an informed view of the nature of science. Furthermore, our analyses suggest that the 2018 PISA Science Score, as a measure of a country's broad science literacy, and the extent to which participants attribute their success/failure to an effective national training, are relevant predictors of achievement in science competitions at the country level. Thus, both aspects, the basic science education as well as specific STEM excellence promotion might need to be addresses to bring forth excellent future scientists.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Approaches to Enhance STEM Teaching
19-Mar-24, 5:15 PM-6:45 PM
Location: Plaza Court 4

Enhancing STEM Teaching to Support English Learners
Catherine Lussier*, University of California, Riverside, USA
Melissa Klaib, University of California, Riverside, USA
Jack Eichler, University of California, Riverside, USA
Leslie Bushong, University of California, Riverside, USA

ABSTRACT
The continued increase of English Learners/Multilingual Learners (ELs) students in the U.S, along with an established achievement gap between ELs and non-ELs in science, technology, engineering, and mathematics (STEM) content areas (NCES, 2019ab), raises concerns regarding teachers' level of preparation to support EL students (Reeves, 2006). The current study's program provides STEM preservice teacher training focused on best practices for teaching EL students. The purpose of the present case study is to evaluate the effectiveness of this year-long program, which includes: (a) coursework on EL language development, (b) fieldwork exposure to research-based teaching experiences with EL students, and (c) professional development for creating hands-on STEM curriculum for diverse learners. Data was collected from five STEM preservice teacher scholars and from a control group of thirty-three in a university credential program. All preservice teachers demonstrated significant growth in their teaching abilities across all six domains of a classroom observation rubric. However, with the additional program training, scholar participants experienced greater growth overall upon program completion and outperformed the control group on five of the six domains. In all, these findings inform educational models for improving STEM-EL teaching and address a crucial need to serve the growing EL population.

Identity Development of Preservice STEM Teachers After Teaching Practicum
Emine Sahin-Topalcengiz*, Mus Alparslan University, Turkey

ABSTRACT
This research frames preservice science teachers' professional identity formation through the lenses of emotions and dilemmas based on semi-structured interviews, practicum reflections, and emotional journals. Six participants participated in the study. Grounded-theory analysis revealed that participants' emotional experiences varied from negative, including anxiety, embarrassment, and anger, sad to positive feelings, including acceptance, pride, and eagerness, from the beginning to the end of the practicums. Furthermore, the participants were faced with dilemmas: (1) acting as a community member or an "outsider," (2) working as an assistant or a "teacher," and (3) the use of conflicting pedagogies while

teaching students. All these emotions and dilemmas contributed to developing preservice science teachers' STEM teacher identity.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Justice-oriented and Humanizing Practices and Critical Stance Science Teaching Perspectives
19-Mar-24, 5:15 PM-6:45 PM
Location: Directors Row E

Examining Pre-service Teacher's Humanization of Science through a Research Experience for Teachers

Matthew Adams*, Michigan State University, USA
David Stroupe*, University of Utah, USA

ABSTRACT

This study examines how Research Experiences for Teachers (RETs) can serve as a potential site through which pre-service teachers (PSTs) can begin to develop their critical consciousness of the discipline of science. By looking for and attending to PST's perspectives on the roles that humans play in science, we seek to identify how and to what extent RETs can support PSTs in humanizing the science that they are charged with teaching. Through this study, we have found that RETs can serve as a place in which PSTs begin to develop a humanizing view of the science, especially when the RET takes place in a racially, ethnically and gender diverse lab.

Investigating Secondary Science Preservice Teachers' Onto-epistemologies as Pathways to Justice-Oriented Science Teaching

Kate Miller*, Michigan State University, USA

ABSTRACT

In this study, I examine secondary science preservice teachers' (PSTs') onto-epistemologies (ways of being and knowing) of science, and inquire about if/how these onto-epistemologies are reflected in the PSTs' beliefs about science teaching and learning. I approach this research with the goal of working towards a vision of justice-oriented science teaching (JOST) and by embracing decolonial perspectives, including the language of settled and desettled onto-epistemologies. Interview data was collected for four PSTs after their completion of a year-long, senior-level science methods course. Initial analysis for the case of one PST shows connections between her desettled onto-epistemology (e.g. science is contextual, scientists are not members of an elite community, science is comprised of multiple narratives) and her justice-oriented beliefs about science teaching and learning (e.g. co-creation of classroom norms, knowledge and meaning, critical questioning the science being taught, using science as a tool towards community change). This study suggests that teacher educators should focus on developing and interrogating PSTs' onto-epistemologies of the discipline of science when preparing PSTs for JOST.

"Students Have the Right to Learn Science": Antiracist Science Teacher Preparation for Elementary Preservice Teachers

Jessica Chen*, Columbia University, USA

ABSTRACT

Preparing the predominantly White teacher workforce to transform elementary science education is still an imperative because racially, culturally, and linguistically diverse young learners still experience differential science learning opportunities in the United States. This case study examined the ways four preservice teachers developed political clarity, justice-oriented science teaching, and antiracist dispositions through their work together in a multicultural science methods course and into two semesters of student teaching during the COVID-19 pandemic. Data sources included initial teacher questionnaires, final course papers, and interviews. The PSTs developed political clarity of how racist policies and structural barriers perpetuated the myth of meritocracy and marginalized science in elementary schools. They developed justice-oriented science teaching through creating a lesson sequence that used science to dispel the social meanings of skin tone while incorporating inquiry, inclusivity, and access. They all developed empathetic dispositions and commitments towards Black children and began to see themselves as teachers with the power to provide more equitable science learning experiences. This study showed that antiracist science teacher preparation consists of strong and explicit learning of where science teaching sits within the broader sociopolitical ideologies of education and science, as well as concrete solutions to transform science learning within classrooms.

Exploring Possibilities for Teaching Science From a Critical Stance Perspective

Elaine Howes*, American Museum of Natural History, USA
Jamie Wallace*, American Museum of Natural History, USA

ABSTRACT

In this paper, we use a qualitative case study approach to explore the roles that one teacher preparation program's components (recruitment, course experiences, practice teaching/residency, and induction) play in preparing and supporting new science teachers in adopting a critical stance toward sociopolitical structures and processes and supporting their students in developing the same. Critical stance, a tenet of culturally responsive education, resonates with this year's theme because a purpose of science education is to develop a knowledgeable citizenry that is able to use science to address "the many socio-scientific issues that are increasingly important in modern society" (Mutegi, 2023). Our findings suggest that the program components play multiple roles in addressing critical stance, including modeling a critical stance and using the affordances of the ISI in course experiences; enacting a critical stance in practice teaching/residency; and supporting graduates in facilitating challenging discussions in induction. Additionally, the recruitment component sets the stage by seeking a diverse group of applicants. We also found that a focus on critical stance, including supporting new science teachers in becoming an ally and advocating for students, could be emphasized more through the program.

From Matter to Mattering: Reconstructing Science Methods Courses Towards Emancipatory Pedagogies and Abolitionist Teaching
Vanessa Louis*, University of Michigan, USA
Natalie King*, Georgia State University, USA

ABSTRACT
This study utilized narrative inquiry (Clandinin & Connelly, 2000) and narrative analysis (Riessman, 1993), to elevate the voices of these early-career Black and Brown teachers. The conceptual framework that informed this study included Love's (2019) abolitionist teaching and Nouri and Sajjadi's (2014) emancipatory pedagogies. Three themes emerged from the narrative analysis, (1) early career science teachers felt more prepared to enter the teacher profession due to the intentional course materials and consistent faculty support, (2) the inclusion of emancipatory pedagogies within the methods course prepared the early-career teachers to affirm the identities of Black and Brown children, and (3) foregrounding abolitionist teaching within the science teacher preparation allowed the early career teachers to see themselves as change agents.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Attending to Equity and Sociocultural Issues in Science and STEM
19-Mar-24, 5:15 PM-6:45 PM
Location: Governor's Square 17

Capturing the Nature of SSI Teaching by using the Five-Dimensions Model of Practice
Dury Bayram*, Eindhoven University of Technology, Netherlands
Yael Shwartz*, Weizmann Institute of Science, Israel

ABSTRACT
Socio-scientific issues (SSI) are effective for developing scientific and citizenship skills. However, it is challenging for teachers for various reasons: limited materials, the multi/interdisciplinarity/emerging nature of SSI, and the incongruence of SSI pedagogy with teachers' identities and beliefs. This study's goals are to capture the nature of SSI teaching and to explore how teachers' knowledge about SSI is manifested in practice. 22 teachers from 10 European countries were observed teaching an SSI lesson and participated in a reflective interview. Bartholomew, Osborne and Ratcliffe's (2004) 5-dimension model of practice was used for analysis. It revealed teachers' patterns and indicated common trends. We could identify teachers with different levels of SSI knowledge (novice to expert). No correlation was found between participating in SSI-PD, or experience in teaching science with the quality of the observed lesson. A correlation was found between teachers' conception of their own role and their learning goals with the quality of the observed lesson (Spearman coefficient 0.71, p=0.0005). Also, most teachers could articulate SSI learning goals but were less successful in providing authentic and dialogic learning environments. Looking at each dimension separately and at possible interactions between them may inform the field to improve SSI teaching.

Communities of Practice in Support of Urban Elementary Teachers' Thinking about Critical Pedagogy of Place

Gail Richmond*, Michigan State University, USA
Roberta Hunter, Michigan State University, USA
Tali Tal, Technion Israel Institute of Technology, Israel
Grace Tukurah, Michigan State University, USA

ABSTRACT
Children who live in under-resourced communities and attend under-resourced schools deserve access to high-quality teachers and educational opportunities to support their success and well-being. This study emerged from a professional development (PD) for urban teachers working in such schools, to expand educational opportunities for elementary students through outdoor science teaching. Engaging frameworks of Communities of Practice (CoP) and Critical Pedagogy of Place (CPP), this critical ethnographic study investigates how urban elementary teachers engage in discourse about critical issues of place. Additionally, the investigation seeks to understand how a CoP supports such discourse. The primary data for this study were multiple sets of researcher field notes collected from participant teachers during spring weeklong summer PD. Over the course of the PD, participants shifted from viewing their outdoor teaching spaces through a deficit perspective to an asset-focused one. As they visited one another's teaching sites, the CoP the teachers were part of allowed for discourse about social justice linked to issues of place within their school neighborhoods. The ability of urban educators to connect social justice to issues of place and to the teaching of science has implications for countering injustices that characterizes many urban communities in the USA and elsewhere.

South African Teachers' Experiences in Positioning Science Education for Equal Access to All Students

Paul Iwuanyanwu*, Northwest University, South Africa
Meshach Ogunniyi, University of the Western Cape, South Africa

ABSTRACT
In an effort to redress past injustices in education, South African science teachers are striving to provide science education that is tailored to the developmental needs of science students from diverse backgrounds. In the absence of much research on this issue, we developed a 24-item open-ended reflective questionnaire and a 12-item semi-structured interview and distributed them to a purposive sample of 150 science teachers in three provinces in South Africa.Using Fraser's social justice framework (i.e., redistribution-fairness of access to quality science education; recognition-elimination of any form of discrimination; and representation-human rights of all citizens regardless of their socio-economic status) shows that despite the curriculum reforms, very little transformation has actually taken place in science education since 1994. The results show that ninety percent of teachers had difficulty reconciling themselves to the view that science education is indeed for all because of their experiences as students and teachers during apartheid.One-third of teachers indicated that providing science education that meet the needs of all students requires significant attention, while

two-thirds indicated that funding allocations for science education appear to favour schools in white communities over those in black communities.These findings have important implications for science education reformers, curriculum planners and policymakers.

"We are better together": An Equity-Focused, Collaboration-Forward Engineering Professional Development Experience for Middle School Teachers

Gina Svarovsky*, University of Notre Dame, USA
Catherine Wagner*, University of Notre Dame, USA
Shannon McManus, Museum of Science, USA

ABSTRACT
Over the past two decades, the increasing inclusion of engineering practices within NGSS and state science standards has fostered a growing need for effective engineering professional development (PD) for pre-college teachers. Field-wide design standards for engineering PD highlight the importance of teachers experiencing the nature and practices of engineering as a pathway to better understanding how engineering connects to other STEM disciplines and STEM learning. Although scholars have called for more equity-focused approaches to engineering education writ large, there has been less focus on integrating these approaches into teacher PD. In this paper, we explore how an equity-focused and collaboration-forward engineering PD may have helped a group of 27 middle school teachers change their perceptions of engineering as a discipline and the ways they might incorporate engineering within their science, math, and STEM-focused classrooms. Teachers report the PD experience broadened their views on engineering, the role and process of collaboration, and engineering instructional practices. Teachers also identified ideas from the PD that they wanted to bring back to their classrooms, such as structured brainstorming and the meaningful integration of real world contexts for their students.

Strand 8: In-service Science Teacher Education
Related Paper Set
Designing Teacher Learning for Promoting 3D Instruction and Assessment
19-Mar-24, 5:15 PM-6:45 PM
Location: Governor's Square 15

Leveraging a School-Based Professional Learning Community to Support Teachers Customization of a Reform-Oriented OER Curriculum.

Austin Moore*, Boston College, USA
Katherine McNeill, Boston College, USA
Maria Morena Vera, Boston College, USA

ABSTRACT
The release of the Framework for K-12 science education and the Next Generation Science Standards required teachers to reimagine science instruction in their classrooms. To support teachers high-quality reform-oriented curriculum materials have become available online through open-source educational resources. These materials give teachers the freedom to

make modifications as needed for their students' context. However, not all modifications add value to the curricular resources, suggesting teachers need additional support to develop the skills to make effective curricular customizations. This study took place within a larger suburban middle school in New England area. A group of researchers worked with four science teachers and two instructional leaders within a structured professional learning community (PLC) to understand how teachers conceptualize their Problem of Practice within a PLC and what elements of the PLC or enactment influence their conceptualization. Findings suggest over the course of the PLC the teachers underwent a process of collective sensemaking that refined what they meant by student engagement and multiple perspectives. Additionally, findings show that moments of productive failure during customization enactment were a valuable process for teachers in refining their customization over time. This study helps to better understand how teachers make decisions around customizing a reform-oriented curriculum.

Curriculum-Based Professional Learning and Teacher Attention to the Epistemic Aspects of Classroom Talk and Collaboration

Chris Griesemer*, University of California Davis, USA
Cynthia Passmore*, University of California Davis, USA
Jessica Alzen, University of Colorado Boulder, USA
Jason Buell, Northwestern University, USA
Kelsey Edwards, Northwestern University, USA
William Penuel, University of Colorado Boulder, USA
Brian Reiser, Northwestern University, USA

ABSTRACT

A movement to student-centered knowledge-building as a core science practice in the NGSS requires teachers to substantially shift classroom pedagogy in terms of student agency and collaborative co-construction of knowledge. In our work, we aim to support these aspects of a shift to sensemaking by engaging teachers in exploring and understanding the epistemic motivations for classroom talk and collaborative work. The context for this paper is a project where we have provided middle and high school teachers with high quality instructional materials and engaged them in ongoing curriculum-based professional learning (CBPL) over the course of two years. We tracked their thoughts about and attention to the epistemic aspects of student talk and collaboration through interviews, reflections and surveys. We analyzed the data using an emergent coding scheme in order to ask, "How does teacher attention to the epistemic aspects of student-centered work and collaboration change as they engage in our CBPL?" The data show that teachers talk about the epistemic motivations decreasing as they move into the context of classroom enactment, suggesting they are continuing to grapple with engaging students in listening to each other as an incremental step in supporting discipline-based conversations involving argumentation and consensus building.

Preparing Rural Teachers to Design Framework-Aligned Assessment Tasks: Variations in Who Learns and Why

William Penuel*, University of Colorado Boulder, USA
Abraham Lo*, BSCS Science Learning, USA

ABSTRACT
This paper focuses on a professional development program designed to support rural secondary science teachers to design tasks to assess student learning that reflect the vision of A Framework for K-12 Science Education. Our approach is grounded in the idea that designing tasks provides a powerful context for learning, but that teachers' own prior knowledge, experiences, and identities will shape what they learn, as do the social and material resources that they have available to them. Interviews and assessment tasks collected from teachers in both a design study and experiment served as data to account for variation in who learned what and why in the program. While we found that overall, the quality of teachers' assessments shifted over time, the results for the experiment were better than for the design study, partly owing to shifts made in tools and coaching and feedback provided in the experiment. A persistent challenge was choosing and problematizing phenomena for assessment. Our sequence of studies shows the potential—as well as intensive labor—associated with iterative design of tools to support teachers in designing assessments aligned with the vision of the Framework.

Fostering Teachers' Ambitious Teaching Practices for Supporting the Implementation of Performance Assessments in Science
Miray Tekkumru-Kisa*, RAND Corporation, USA
Jill Wertheim*, WestEd, USA

ABSTRACT
Achieving the vision of teaching and learning outlined in the Framework for K-12 Science Education will require teachers to attend to students' initial intuitions and emerging ideas, pursue their thinking, and respond in ways that will help students engage in three-dimensional knowledge building (e.g., Ko & Kirst, 2019). This paper focuses on a PL program that uses the implementation of IEAs as a laboratory for teachers to work with students' ideas and to use ambitious science teaching principles to advance their thinking. In this study, we seek to understand the impacts of this PL model on teachers' learning and to identify specific design elements that were instrumental in their learning. Analysis of the PL sessions and interviews with teachers revealed fundamental changes in how teachers recognized evidence of students' 3D thinking and their intentionality around eliciting, noticing, and working with students' 3D thinking. Interviews point to the central role of the IEAs, and video clips of their implementation, in transforming teachers' thinking. The study findings have implications for the design of PL to support teachers' learning at the intersection of assessment for learning and ambitious science teaching.

Core Practices of Storyline Instruction for Reforming Novice Teacher Education
Sage Andersen*, The University of Texas at Austin, USA
María González-Howard, The University of Texas at Austin, USA

ABSTRACT
Seeking to realize the vision for 3D science education put forth in the NGSS (NGSS Lead States, 2013), Reiser and colleagues (2017) proposed a storyline approach to science teaching

and learning that positions students as both capable scientific sensemakers (Warren et al., 2001) and epistemic agents (Stroupe, 2014) whose questions and ideas drive the classroom community's knowledge construction work. Currently, little research has explored how preservice teachers (PSTs) - or novice teachers who teach in schools or district that have adopted curricula that do not follow the storyline model - learn to teach using this instructional approach. To support teachers in taking up storyline instruction as practice, we must first identify the core practices that make up this instructional approach (i.e., those that occur in high frequency in storyline instruction, which novice teachers can begin to master, and that can be enacted in classrooms across different curricula or contexts; Grossman et al., 2009). In this conceptual piece, we propose six core practices for storyline instruction that can be used to organize and support novice teacher learning– work which is necessary for reforming teacher education spaces to truly realize goals of 3D science learning.

Strand 10: Curriculum and Assessment
Related Paper Set
Innovative and Equitable Curriculum, Instruction, and Assessment Resources Aligned with the Next Generation Science Standards
19-Mar-24, 5:15 PM-6:45 PM
Location: Directors Row J

Overview of Project Goals, Design Frameworks, & Products
James Pellegrino, University of Illinois Chicago, USA
Ellen Forte*, edCount, USA

ABSTRACT
Curriculum and assessment development initiatives are all too often carried out independently from each other. Consequently, educators lack science curricula and assessments that work together to support teaching and learning. This often leads to lack of alignment between the curriculum goals, assessment, and instruction that in turn does not ensure students receive meaningful and adequate learning opportunities that they can apply to real life situations. Our work provides a solution to this problem by building a coherent system that aligns curriculum, assessment, and instruction. To achieve such coherence at the level of instructional units for Grades 5 and 8, we employed multiple design frameworks to guide development of critical components and their coordination and alignment across curriculum, instruction, and assessment. The conceptual and design frameworks included: Understanding by Design, the Assessment Triangle, Evidence Centered Design, and Learning Progressions in Science. This first paper will overview the rationale for and the logic of the integrated curriculum-instruction-assessment development model and the specific design processes employed that work synergistically to yield all the major elements of the system. The material reviewed will set the stage for detailed discussions of key components of the work subsequently covered in the other papers of the set.

Illustration of the Curriculum Map and Resources for a Grade Level Unit
Erin Buchanan, edCount, LLC, USA
Charlene Turner*, edCount, LLC, USA

ABSTRACT
The collaborative has produced year-long model courses with four unit maps each at grades 5 and 8 grounded in phenomena and NGSS thematic or topic bundles. The unit maps were developed in partnership with groups of state and local educators from the partner states through the application of Understanding by Design (UbD; Wiggins and McTighe, 1998/2005). This framework organizes instruction into 3 stages: Stage 1 – Desired Results, Stage 2 – Assessment Evidence, and Stage 3 – Learning Plan. Known as "backwards planning," the UbD approach begins with the desired results and works backwards to determine the assessment evidence and learning plan. This approach ensures that teachers are deliberately planning their assessments and lessons with a focus on the expected objectives of what students should know and be able to do at the end of each unit, thus promoting coherence in their curriculum, instruction, and assessment system. This second paper will illustrate the design approaches, application of methods, and resultant products for the instructional resources for content area units at each grade level, focusing on the first two stages—Stage 1: Desired Results and Stage 2: Assessment Evidence—of UbD as exemplified in the SIPS Grade 8 Unit 1 map.

Example of the Stage 3 Learning Plan for a Grade Level Unit
Jared Ten Brink*, University of Michigan-Ann Arbor, USA
Mary Nyaema, University of Illinois-Chicago, USA
Donald Wink, University of Illinois-Chicago, USA
Sania Zaidi, University of Illinois-Chicago, USA

ABSTRACT
Today teachers are challenged to provide customized instruction which also meets defined standards and expectations in order to prepare students for success. This paper and presentation will provide an overview of an instructional learning plan which provides potential structure and guidance as teachers develop their instructional sequence. We will review the overall design, key features and components, and the design process for one sample learning plan. The impact for future curriculum development work and significant findings will be discussed.

Examples of End of Unit (EOU) Assessments with Discussion of a Pilot Study Results
Howard Everson*, City University of New York, USA

ABSTRACT
The Project's system of assessments included multiple opportunities to collect evidence of student learning. The assessments were, by design, aligned to the NGSS performance expectations and allow for inferences of student achievement within the framework of interpretations of the Next Generation Science Standards (NGSS). The project produced four EOU assessments at each of two grade levels (5th and 8th grades). The assessments were

designed to be administered at the culmination of each instructional unit. Each EOU assessment included three tasks with multiple prompts. The development of each EOU assessment is informed by the Guidance for Equitable Assessments for Diverse Learners (Designing Equitable Assessments for Diverse Learners). The prototype EOU assessments were pilot-tested in schools across the project's six partner states. The Grade 5 EOUs were administered to a cohort of 435 students, and the Grade 8 EOUs were administered to a cohort of 145 students. This paper will present illustrations of EOUs, examples of students' performances on these tasks, and a summary of students' performance on EOUs at each grade level. The findings will be discussed in terms of what they say about students' science learning and how those results led to modifications of the EOU task designs.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set
Perspectives of Curriculum Adaptation and Core Ideas
19-Mar-24, 5:15 PM-6:45 PM
Location: Directors Row H

Collaboration for Curriculum Implementation in Lesotho: Insights From a Distributed Instructional Leadership Perspective

Nthooa Lisene*, University of the Free State, South Africa
Loyiso Jita, University of the Free State, South Africa

ABSTRACT

School leadership has the potential to positively influence instruction, even though it remains undervalued. This mixed methods research explored the distributed instructional leadership of the HoDs in the implementation of the new integrated curriculum in Grade 8 through a convergent parallel design. The sample consisted of 67 schools selected through concurrent nested random cluster sampling. Quantitative data were collected through an instructional leadership questionnaire and analysed through statistical analysis software. Qualitative data were collected through interviews and document analysis, thus analysed thematically. The findings reveal that the HoDs facilitated collaborations in terms of sharing pedagogical content knowledge and instructional materials, even though they believed that the new curriculum has an adverse impact on the quality of education. This study outlines functional distributed instructional leadership functions employed to improve the implementation of the Science and Technology curriculum in Grade 8 including consultations, continuous professional learning, and context assimilation, among others. We recommend the employment of other methods of curriculum integration which are more suitable for secondary school settings, as well as more collaborations between the government, schools, and subject associations.

Exploring Core Ideas: A Systematic Literature Review of Core Ideas in Science Education

Helen Semilarski*, University of Tartu, Estonia
Helin Semilarski, University of Tartu, Estonia

ABSTRACT
A systematic literature review (SLR) of academic articles was undertaken to gain an overview of the conception of core ideas and related aspects. The keywords used for the search were the following: "core ideas" OR "big ideas" AND "science education". After meeting the inclusion and exclusion criteria, 106 articles were used in this systematic literature review. Overall, school education should enhance students' core ideas so that they can become informed participants in society. The results of this study emphasize the need to put more focus on core ideas. To identify disciplinary and interdisciplinary core ideas taught in the school program and create meaningful models and frameworks on how these are progressing throughout the school years.

Exploring the Level of Content Knowledge Emphasis Among Botany Curriculums of Public Universities in Bangladesh

Sheikh Tahmina Awal*, Institute of Education and Research, University of Dhaka, Bangladesh

ABSTRACT
Establishing knowledge of the subject matter is crucial to higher education quality. Departments with identical subjects at different institutions of tertiary education produce graduates with vastly varied skill sets including content knowledge, resulting in discrimination in their employability. This study explored the level of content knowledge emphasis among the Botany curriculums of different public universities in Bangladesh. This study explores the levels of content knowledge emphasis among the Botany curriculums of different public universities in Bangladesh. A qualitative multiple-case study method is employed to understand the phenomenon. In the first phase, relevant documents were analyzed, and in the second phase, interviews and focus group discussions (FGDs) of stakeholders were conducted. The study employs document analysis frameworks, interview schedules, and FGD guidelines as instruments. Data was analyzed through content analysis for relevant documents and thematic analysis of collected evidence. The analysis revealed a mismatch among the selected cases regarding the emphasis of knowledge in course areas in their curriculum. As content selection for students' learning is aligned with meaningful learning, this mismatch may affect their learning achievement and their profile. The research findings carry implications for knowledge development, teaching-learning practice, policymakers, curriculum developers, and future researchers.

A Teacher's Journey Through Co-designing and Adapting Curricular Materials

Katarzyna Pomian Bogdanov*, Northwestern University, USA

ABSTRACT
Teachers often rely on curricular materials as support for implementing reform-based science practices and as educative materials to continue developing ways in which they teach and approach science. Therefore it is important to understand how teachers develop and use curricular materials and how they learn from their experiences. However, we lack deeper dives into longitudinal relationships that teachers have with curricular materials. This study explores the ways a teacher designs and adapts curriculum over three years. The study tracks the teacher's involvement in co-designing curricular materials alongside other

teachers, researchers, and curriculum designers and adapting and using these materials in her own classroom. The study will focus on a moment in class that the teacher was particularly proud of because it created a palpable shift in the students' engagement with the content she was teaching. This study aims to draw a narrative of this teacher's journey across her three years of writing and adapting materials she was using.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set
Empowering Students in Engineering: Ethical and Transformative Learning Approaches for a Socially Conscious Future
19-Mar-24, 5:15 PM-6:45 PM
Location: Plaza Court 3

Cultivating Community Connections between Undergraduates and Elementary Students through the Co-Design of Engineering Games
G. R. Marvez*, Tufts University, USA
Greses Pérez, Tufts University, USA

ABSTRACT
STEM games can be a tool for engaging students in learning about complex systems, but many learning games are not localized to students' community and cultural context. In this study, we explore how undergraduate students in a first-year engineering class co-design learning games about local engineering challenges with local elementary students. Through this work, we investigate how students as designers can create educational games to interact with complex systems and envision themselves in future STEM careers. These designs may provide insights into how to co-design educational games with students that represent their communities and their ways of understanding STEM challenges.

Fostering Critical Consciousness: Faculty Impact on Teaching Social Responsibility in Engineering Education
Sindia Rivera-Jiménez*, University of Florida, USA

ABSTRACT
In a world where the demand for socially conscious engineers is paramount, this study uncovers how faculty members' grasp of societal dynamics informs their teaching techniques. Engineering faculty members' critical consciousness about societal and power structures and their influence on teaching social responsibility are explored through the lens of two perspectives: critical consciousness (Mejia et al., 2018) and the Transformational Agency (Bajaj, 2018) framework. Participants were drawn from an 8-month Community of Practice (CoP) comprising multi-institutional chemical engineering faculty facilitated by a national professional organization. Data collection involved observing CoP sessions and conducting three semi-structured interviews with two consenting participants. The data were analyzed using thematic analysis (Clarke, 2021). This approach considered a priori codes based on the research questions and theoretical perspectives while remaining open to

discovering 'new' codes and themes emerging from the data (Saldaña, 2016). The findings show the nuanced impact of peer interactions within the CoP on faculty members' reflective practices and their understanding of societal and power structures, significantly shaping their development of critical consciousness in teaching social responsibility. By examining how faculty members develop critical consciousness, this study can identify key factors that facilitate or hinder the integration of these principles into the curriculum.

Engineering Students' Epistemologies in Design Problem Solving: Exploring the Gap Between Professed and Enacted Epistemologies
Trevion Henderson*, Tufts University, USA
Joshua Cohen*, Tufts University, USA

ABSTRACT
Students' personal epistemologies play an important role in team-based engineering design. However, research consistently finds that what students say they believe about engineering knowledge in the abstract differs from what one might deduce about their epistemologies from their behaviors. Drawing on the epistemological resources framework, our research was guided by two questions: (a) What are the characteristics of engineering students' professed and enacted epistemologies? (b) What are the contextual dynamics that explain differences between students' professed and enacted epistemologies.
We conducted focus groups with engineering students in two stages. In Stage 1, we captured students professed epistemologies using handwritten surveys. In Stage 2, we captured students' enacted epistemologies by asking them to evaluate the rationales presented by five engineers facing a critical design decision.
Our findings suggest that while students expressed support for the inclusion of non-technical knowledge in engineering decision making, students consistently objected to non-technical knowledge in practice. The gap between students' professed and enacted epistemologies appears to be shaped by patterns of influence between students. We argue that social power dynamics can serve as a cue that activates students' epistemological resources, shaping how students think through engineering decisions in practice.

Renegotiating Roles & Responsibilities in an Undergraduate Engineering Design Course
Monica Cardella*, Florida International University, USA
Alexandra Strong, Florida International University, USA
Stephen Secules, Florida International University, USA
Trina Fletcher, Florida International University, USA

ABSTRACT
Community-Based Learning is increasingly recognized in engineering education for its collaborative approach between students and community partners. This study investigates the nature of students' relationships with community partners in such settings, exploring whether students perceive partners solely as recipients of assistance or as valued sources of expertise. Drawing on scholarship that emphasizes the social nature of both design and learning, this research examines engineering students' experiences in an undergraduate engineering course focused on human-centered design and systems thinking at a large

Hispanic-Serving Institution. The findings suggest that when groups were first formed during the fourth-class session, the group planned to focus on "maintenance workers", but by the end of the class period they shifted their focus to "non-profit organizers." This shift allowed members of the group to center community members that they had long-standing relationship with, where they were able to use their course assignment work to continue to work with leaders from local non-profit organizations in ways that were personally meaningful to the students and respectful towards the community partners. This study contributes to ongoing discussions in community-based pedagogies by emphasizing the reciprocal nature of student-community partnerships and the need to value students' contributions in engineering design experiences.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
STEM Identity Trajectories: Intersectional Interplays of Capital, Aspirations, and Resistance
19-Mar-24, 5:15 PM-6:45 PM
Location: Plaza Court 1

Young Women's STEM Trajectories, Age 10-22: Intersectional interplays of Identity, Capital, Field and 'Luck'
Louise Archer*, University College London, United Kingdom

ABSTRACT
This paper focuses on the factors shaping young women's STEM trajectories through a sociological analysis of UK longitudinal interview data collected as part of a study of young people's STEM pathways, age 10-22. Conceptually, the paper is informed by work on (i) intersectional STEM identity work (ii) Bourdieusian scholarship on interactions of STEM-related forms of habitus, capital and field and (iii) the sociology of luck, specifically the potential for interplays of agency and structure within young people's lives that disrupt hegemony and social reproduction.
Data are drawn from a wider convergent parallel, mixed methods study of young people's educational and career trajectories, focusing on 114 longitudinal interviews conducted with a subsample of 19 young women from age 10-22. Analysis considers their navigation of routes into or out of STEM through six illustrative longitudinal case studies, highlighting how and where key themes resonate with and illustrate findings from the wider sample. The paper concludes with implications for STEM education policy and practice, suggests new metaphors for understanding young women's STEM trajectories and argues for responses that address both a politics of recognition and redistribution that focus on changing the relations of injustice that create and sustain injustices in STEM.

Supporting First-Generation Refugee Families' STEM Aspirations and College Navigation
Eugene Judson*, Arizona State University, USA
Mohammed Ibrahim, Arizona State University, USA

ABSTRACT
The challenges faced by first-generation students, particularly within refugee communities, can be formidable as they aspire to attend an American university and pursue a professional career. These challenges include uncertainties in navigating the path from high school to college, limited awareness of various STEM career fields, and a lack of acquaintances who have successfully navigated similar paths. Complexities such as high school graduation and university admission requirements, coupled with few higher education connections, contribute to the frustrations experienced by parents and students.
To address these issues, we present the results of a project aimed at promoting STEM aspirations, and enhancing the understanding of college navigation among refugee families residing in the United States. The project focused on parents and their children in grades 7-12 and was a collaboration between a large public university and leaders of several ethnic community-based organizations (ECBOs) representing local Burundian, Congolese, and Syrian communities. Results indicate the project positively affected students and parents' STEM capital and college social capital, as well as students' expectations regarding how fulfilling a STEM career might be.

STEM Identity Progression/Evolution in Black Students: From Undergraduate HBCUs to Graduate PWIs
Karen Marshall*, Oakwood University, USA
Carmen Bucknor*, Oakwood University, USA
Sylvia Butterfield*, National Science Foundation, USA
Christyn Byrd*, University of Alabama in Birmingham, USA

ABSTRACT
The purpose of this qualitative study is to understand how personal and social factors that contribute STEM identity development in diverse students from historically, Black, colleges and universities (HBCUs) change over time, while also exploring the role of science capital and social capital. Students who participated in focus group interviews in 2020 as undergraduates were interviewed three years later while enrolled in graduate and professional school studies. Results of focus groups using semi-structured interviews suggest that STEM identity evolved, becoming more robust and mature, showing a greater understanding of recognition as a scientist and performance in science settings. Additionally, science capital and social capital persisted and bolstered students' perceptions of competence in the predominantly White institution (PWI) context. This study builds upon the established knowledge 1) that HBCUs graduate a significant percentage of African American STEM majors, 2) HBCUs are facilitative environments for social capital and science capital for African American students, and 3) the pathway to a STEM career or to that of a "scientist" for an African American student includes factors related to identity that connect to community, credible authority, peers, and self all seem to evolve simultaneously in a "mandala-like" form.

Asian and Asian American Women in STEM: Stories of Challenge and Resistance
Jasmyne Yeldell*, University of North Carolina, USA
Dionne Cross Francis, University of North Carolina, USA

Pavneet Kaur Bharaj, California State University, USA
Anina Mahmud*, University of North Carolina, USA
Raven Walters, University of North Carolina, USA
Kerrie Wilkins-Yel, University of Massachusettes, USA

ABSTRACT
Examining participation in STEM through the lens of race and gender show varying participation in achievement. Looking beyond the numbers, we hear stories of success, challenge, exclusion and resistance as attempts to fully engage professionally can risk one's psychological and emotional wellbeing, especially if your identity lies at the intersection of race and gender. The experiences of Women of Color are bounded by the socio-historical and political context of what it means to be both a woman and a person of color. Experiences of Asian and Asian American (AAW) are nuanced as they are considered to superior by race but underrepresented by gender. The complexity of their experiences is amplified when we take into account culture, context, and other identities (e.g., immigrant). As many marginalized communities do, we observed that AAW drew on their familial and community resources, (i.e., different forms of community cultural wealth), for strength and to resist the isolating and exclusionary context of their STEM programs. We discuss practical implications of our findings.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set
Technology for Science Learning 3
19-Mar-24, 5:15 PM-6:45 PM
Location: Plaza Court 5

Comparing Two Iterations of a Place-Based Socioscientific Issues Course Embedded with Different Extended Reality Applications
Mark Newton*, East Carolina University, USA
Len Annetta*, East Carolina University, USA

ABSTRACT
This qualitative study examines two iterations of an undergraduate course that utilized a socioscientific issues approach with embedded extended reality (XR) technology to determine the extent to which XR technology can be used as a pedagogical tool in SSI instruction. The focal issue of the course is climate change resilience and mitigation on the Outer Banks of North Carolina, USA. Qualitative data from the first iteration of the course guided the modifications made to the second iteration. These changes included employing different applications, improving placement of embedded information within the XR experiences, and refraining the issue to better align with the XR experiences. Analysis of the second iteration indicated that the technology had positive impacts on student engagement and learning, including developing a more sophisticated understanding of the issue.

Framing the Hybrid: A Multi-Dimension Perspective

Ehud Aviran*, Weizmann Institute of Science, Israel
Ron Blonder, Weizmann Institute of Science, Israel

ABSTRACT

The past two decades witnessed a rise in use of complementary and alternative methods to Face-to-Face (F2F) teaching, specifically with the advancements in technology. Despite this influx of innovativeness and ingenuity, the concept of hybrid teaching, which is the scale gauging the combination of F2F with other means, is limited to the dichotomy of online-offline. In this work, we suggest a new approach to the concept of hybridity, which arose from analysis of case studies, related to the use of technology during the shift to remote teaching due to the spread of Covid-19. This qualitative study builds on prior work to elucidate a set of scales, acting as axes upon which a hybrid profile could be established for a specific activity or lesson, or even a specific teacher. The pedagogical considerations depicted in the results illustrate axes regarding level of teacher support, utilization of data to advance teaching, the character of the teacher as developer, and more.

Analysis and Evaluation of Socioscientific Issues Collaborative Argumentation from Interpersonal Neural Synchronization Perspective

Yangchunxiao Wang*, Beijing Normal University, China
Yong Xie, Beijing Normal University, China
Xingda Li, Beijing Normal University, China
Shuhao Yang, Beijing Normal University, China
Dana Zeidler, University of South Florida, USA
Chunming Lu, Beijing Normal University, USA
Yonghe Zheng, Beijing Normal University, China

ABSTRACT

Collaborative argumentation based on Socioscientific Issues (SSI) has garnered significant attention in educational studies. However, the extent to which many of the assessments and analyses can be supported by neuroscience remains to be determined. To bridge this gap, the present study employed brain imaging techniques (fNIRS) and methodologies to examine collaborative argumentation among 62 dyads of college students (n=124). Interpersonal Neural Synchrony (INS) has been evolving as a potential marker for predicting learning outcomes and interaction quality. The findings revealed that groups engaging in high-quality argumentation exhibited more pronounced INS. Additionally, dyads showcasing superior collaborative argumentation performance demonstrated greater frequency and higher-quality rebuttals, with the rebuttal phase showing heightened INS levels in the dorsolateral prefrontal cortex (DLPFC). The neural data outcomes suggest that the rebuttal phase serves as a valid indicator of collaborative argumentation quality. Furthermore, this study systematically coded different reasoning modes within argumentation and discovered that high-quality argumentation displayed a notably higher proportion of rational and emotional reasoning modes. Moreover, INS demonstrated a notable increase in the emotional and rational reasoning modes compared to the intuitive ones. This study offers

educators an insightful lens for interpreting educational practices through fundamental neural research.

From Chalkboard to Keyboard: Effect of Paced-Flexible-Model on Achievement in Evolution via a Virtual-Learning-Environment

Franklin Onowugbeda*, Lagos State University-ACEITSE, Nigeria
Peter Okebukola, Lagos State University-ACEITSE, Nigeria
Juma Shabani, University of Burundi, Burundi
Deborah Agbanimu, National Open University of Nigeria, Nigeria

ABSTRACT

This scholarly publication explores the intricate progression of the educational setting from chalkboard to keyboard by investigating the impact of the Paced-Flexible-Model on the achievement of students via a virtual learning environment. The research design in this study employed mixed methods, combining both qualitative and quantitative data collection techniques. The sample consisted of 90 senior secondary school II students (11th grade in the US) purposively selected from two Lagos State educational district V schools in Nigeria. Quantitative data was collected using the Evolution Achievement Test, with a reliability value of 0.79. Additionally, qualitative data was obtained through the use of the Students' Perception of PFM Interview Guide. All students in the two sampled schools used for the experimental and control groups took a pre-test. The experimental group ($n = 47$) got four weeks of PFM-based evolution instruction via a virtual learning environment. Without PFM components, the control group ($n = 43$) learned the same concept as the experimental group. All students took a posttest on the same evaluative measure at the end of the treatment. The ANCOVA output demonstrated a statistically significant difference in academic achievement $F(1, 87) = 7.54$; $p<.05$.

Strand 14: Environmental Education and Sustainability

SC-Organized Paper Set

Sustainability Literacy

19-Mar-24, 5:15 PM-6:45 PM

Location: Directors Row I

Environmental Attitude’s Role in Student-Centered Learning About the Forest Ecosystem and Sustainability

Tessa-Marie Baierl*, University of Bayreuth, Germany
Franz Bogner, University of Bayreuth, Germany

ABSTRACT

Schools are platforms for learning and strengthening competencies about nature preservation. Yet, despite being faced with the same learning opportunities, learning outcomes are very heterogeneous. In this study, we investigated environmental knowledge gains and retention after participation in a student-centered learning program (i.e.,

collaborative, hands-on, and autonomy-supportive), and environmental attitude's role in learning. 261 students participated in our 180 minutes educational program about the forest ecosystem and related sustainability topics. We measured environmental knowledge three times: before the program (pre-test), right after program completion (post-test), and six weeks after program completion to test long-term performance (retention test). Knowledge scores increased right after program completion and decreased in the retention test but remained significantly above pre-test scores. We then analyzed attitude's role in learning using the Rasch model. Attitude had a considerable effect on knowledge scores of each test point, though effects on pre- and retention scores were substantially larger. It indicates that students with positive attitudes knew more before the program and retained more knowledge over time. Surprisingly, the retention scores of those students with the most positive attitudes exceeded their post-program scores, which suggests further immersion into the topic after program completion, rendering attitude a lever for learning.

Comparison of Rural and Urban Secondary School Teachers' Perceptions About Sustainable Development and Sustainability Competences

Anne Laius*, University of Tartu, Estonia
Rolf Saarna, University of Tartu, Estonia

ABSTRACT

Sustainable development (SD) is a multidimensional approach that recognizes the interconnectedness of the environment, economy, and society. It has been recognized as the pathway to a sustainable future for all. Sustainability literacy (SL) refers to the knowledge and understanding of sustainability concepts, principles, and practices. It is becoming increasingly important in today's world due to the pressing environmental, social, and economic challenges we face. SL plays a vital role in education and raising awareness about sustainable development. It empowers individuals to understand and critically evaluate sustainability-related information, enabling them to be active and engaged citizens. By promoting SL in education, we can equip current and future generations with the knowledge, skills, and values needed for sustainable world. The aim of the current study is to investigate whether the secondary school teachers' perceptions about SD and sustainability competences are influenced by the rural or urban geolocations of their schools. Twenty teachers of different subjects from two secondary schools conducted semi-structural interviews and qualitative content analyzes utilizing QCAmap software by two researchers and Cohen's Kappa is calculated to validate the data. The preliminary results revealed the impact of the location of school on teachers' perception about SL and sustainability competences.

A Coastal Ecology Summer Course: Engaging Future Photographers, Policy Makers, Engineers, & Community Workers

Hamza Malik*, University of Massachusetts, USA
Rachel Stronach*, University of Massachusetts, USA
Stephen Witzig*, University of Massachusetts, USA

ABSTRACT
Coastal communities are most at-risk for climate change issues. To mitigate these environmental issues sustainably, we must acknowledge the role of education, especially when engaging students in out-of-classroom experiences, i.e., nature centers. There is limited research that provides students' engagement perspectives in this context. This exploratory research study aimed to understand how a summer coastal ecology course utilizes student-centered activities to engage students in learning experiences beyond their classroom settings. We utilized multiple data sources, such as student interviews and student classroom discussions, as our primary data sources. We also used educators' observation notes and student worksheets as secondary sources. We collected data from 15 students from the 2022 and 2023 summer program cohorts and utilized constant comparative analysis to connect our assertions with our conceptual framework. Our four assertions included 1) engaging students as nature photographers spark valuable discussions, 2) engaging students as policymakers allows them to understand human impacts on coastal communities, 3) engaging students as engineers allows students to utilize their problem-solving skills, and 4) engaging students as community workers allow students to take action on various environmental issues. This study would benefit science education faculty, staff at science centers, curriculum developers, administrators, and educational researchers.

Context Matters When Assessing Science Civic Engagement in Science Literacy Students

Jennifer Teshera-Levye*, University of Nebraska-Lincoln, USA
Irfanul Alam, University of Colorado, USA
Lisa Corwin, University of Colorado, USA
Jenny Dauer, University of Nebraska-Lincoln, USA

ABSTRACT
Students require both a core set of science literacy skills and the knowledge of how to apply those skills to their lives as members of civic society. Science civic engagement (SCE) is the set of knowledge, actions, self-efficacy, and values that students hold about applying their science skills to the betterment of their communities. In order to use science literacy skills in this way, students must be able to transfer their competencies from the classroom to their community. In this study, we investigate the way assessment context influences this transfer. In a large, lecture-based science literacy course, students learned skills through decision-making on multiple socioscientific issues (SSIs). We compared an assessment of SCE, the PSCE instrument, from beginning to end of semester in two modalities: one framed around a community, and one framed around an SSI covered in the course. We found that while community-framed SCE was significantly higher at the beginning of the semester, only issue-framed SCE increased significantly at the end of the semester. This suggests that science literacy skills translate more readily to SCE when assessment context matches learning context, which has important implications both for assessing and teaching students to use science to improve their communities.

Graduate Student Committee
Sponsored Session
Graduate Student Forum
19-Mar-24, 6:45 PM-7:45 PM
Location: Plaza Ballroom ABC/DEF

Graduate Student Forum

ORGANIZERS
Jennifer Bateman, Clemson University, Augusta, Ga, USA
Amy Padlof, FIU, USA
Beyza Okan, Bogazici University, Turkey
Justin Andersson, University of Nebraska, USA
Johan Tabora, University of Illinois Chicago, USA
Kristal Turner, University of Calgary, Canada
Zhongyan Zhang, University of Leeds, United Kingdom
Lauren Wagner, Florida State University, USA

ABSTRACT
The Graduate Student Forum hosts round table discussions, which focus on topics that range from preparing for the job market to networking. There are a minimum of eight tables for graduate students to choose from, facilitated by experts in the field. The topics are selected based on feedback from the graduate students themselves. There are two roundtable sessions of 30 minutes each during the session.

Social Event
STEM Trivia Night!
19-Mar-24, 6:45 PM-7:45 PM
Location: Governor's Square 15

STEM Trivia Night!

ORGANIZERS
Margaret Blanchard, NC State University, USA
Matt Reynolds, NC State University, USA

ABSTRACT
Calling all Trivia fans! We are taking our NC State STEM Trivia Night on the road to Denver. A friendly competition with your NARST colleagues (no iphones allowed if you want to win) will lead to the top three teams, who will earn bragging rights. Bring a team or find new friends. We will display clues on a big screen and you will fill out a shared sheet at your table for several rounds of wide-ranging STEM trivia questions.

Indigenous Science Knowledge (ISK-RIG)
Social Event
Fireside Chat: Networking, Socializing and Getting to Know and Learn From and With ISK-RIG Enthusiasts
19-Mar-24, 6:45 PM-7:45 PM
Location: Governor's Square 14

Fireside Chat: Networking, Socializing and Getting to Know and Learn From and With ISK-RIG Enthusiasts

ABSTRACT
The goal of this social event is to provide lowkey, dynamic, and friendly environment to all attendees who are interested in and want to know more about works that are going on in the areas of Indigenous Science Knowledge across the globe. Furthermore, this will be a space for young scholars, graduate students, practitioners, and others to socialize and network with established scholars who are engaged in the ISK fields. All interested NARST members from all areas are welcome to attend this event and socialize with ISK-RIG members and scholars and build a network for future collaboration or just come and get to know someone who you have never met before.

Continental and Diasporic Africa in Science Education (CADASE)
Social Event
CADASE Social: Reconnecting Across the Diaspora
19-Mar-24, 6:45 PM-7:45 PM
Location: Governor's Square 12

CADASE Social: Reconnecting Across the Diaspora

ORGANIZERS
Rona Robinson-Hill, Ball State University, USA.
Shari Watkins, American University, USA

ABSTRACT
The CADASE Social provides a physical space at the NARST Annual International Conference 2024 in Denver, CO for current members to reconnect and afford potential new members opportunities to learn more about the CADASE RIG. In this interactive event, scholars will play an assortment of games and fellowship to continue to build community among members where both personal relationships and professional collaborations can flourish.

Fellows Program
Social Event
NARST Fellows Inaugural Gathering (Invited Social Event)
20-Mar-24, 7:00 AM-8:00 AM
Location: Directors Row I

NARST Fellows Inaugural Gathering (Invited Social Event)

ABSTRACT
The purpose of this inaugural NARST Fellows breakfast is to bring together the NARST Fellows — from 2021 when this program launched to 2024 — as a cohort to: (1) celebrate their achievements and contributions, (2) introduce the Fellows to one another, (3) discuss the vision and goals for the NARST Fellows Program, and (4) brainstorm NARST-related activities and events that could be led or contributed to by the Fellows. NARST Fellows are accomplished scholars and community members representing a diversity of racial, linguistic, gender, and other identities, from around the world and from various epistemological traditions, whose scholarship, service, and leadership activities advance the NARST community and the field. This inaugural gathering will be crucial for successfully growing the NARST Fellows Program and for leveraging the Fellows' expertise towards fostering a sense of pride and community in the NARST organization. By the end of this event, our goal is to develop an initial set of activities and milestones through the Fellows Program that will advance the mission of NARST within and beyond the organization, with concrete timelines for accomplishing them.

20 MARCH 2024

Committee Meeting
Strand 1 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 10

Committee Meeting
Strand 2 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 11

Committee Meeting
Strand 3 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 12

Committee Meeting
Strand 4 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 14

Committee Meeting
Strand 5 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 16

Committee Meeting
Strand 6 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Governor's Square 17

Committee Meeting
Strand 7 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 8

Committee Meeting
Strand 8 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 2

Committee Meeting
Strand 10 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 3

Committee Meeting
Strand 11 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 4

Committee Meeting
Strand 12 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 5

Committee Meeting
Strand 13 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 6

Committee Meeting
Strand 14 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Plaza Court 7

Committee Meeting
Strand 15 Meeting
20-Mar-24, 7:00 AM-8:00 AM
Location: Directors Row E

Plenary Session
Membership and Business Meeting
20-Mar-24, 8:15 AM-9:15 AM
Location: Plaza Ballroom ABC/DEF

Graduate Student Committee
Sponsored Session
Graduate Student Research Symposium
20-Mar-24, 9:15 AM-10:45 AM
Location: Governor's Square 10

Graduate Student Research Symposium

ORGANIZERS
Savannah Graham, University of Houston, USA
Justin Andersson, University of Nebraska- Omaha, USA
Johan Tabora, University of Illinois at Chicago, USA
Mutiara Syifa, The Ohio State University, USA
Alyssa Freeman, Middle Tennessee State University, USA
Andrea Reeder, Middle Tennessee State University, USA
Austin Jenkins, Purdue University, USA
Sierra Morandi, Florida State University, USA
Cathy Cullicott, Arizona State University, USA
Allison Metcalf, Florida State University, USA

ABSTRACT
The purpose of this symposium is to support graduate students as they develop their research projects by providing an opportunity to present works-in-progress and receive feedback from a symposium advisor in addition to NARST attendees. The works-in-progress are emerging research undertaken by yourself as a graduate student where you started collecting data or began to analyze the findings with support from NARST members.

Bamidele, Bolaji; Utah State University. Crafting and Negotiating Localized STEM Identities in an Autonomy-Supportive Physics Afterschool Program for Refugee-Background Youth

Browning, Lauren; George Washington University . Ten Years of NGSS: Documenting Researchers use of Fidelity of Implementation

Cannon-Force, Brandi; Stanford University. Centering Community Knowledge Holders: Perspectives on Black Science Epistemology, A Delphi Study

Evans, Sam; University of Wisconsin, Madison . How Science Teachers Improvise Identities to Manage Disconnects Between Science Inside and Outside the Classroom

Garcia, Liliana; University of California Santa Barbara. "Who Will I Be?": Examining Girls' Identity Exploration In Quantum Information Science Through Video Games

Hadas, Boaz; Technion- Israel Institute of Technology. An Examination of Knowledge Types Harold, Sera; North Carolina State University. Among Pre- and In-Service Chemistry Teachers with emphasis on Self-regulated Learning

Into the Weeds: A Grounded Theory of One Facebook Group's Impact on its Members' Pro-environmental Behavior

Hong, Seongeon; Seoul National University, South Korea. Exploring Preservice Teachers' Integration of Pedagogy with Modern Physics Experiments

Ijaz, Muhammad Usman; University of Massachusetts Dartmouth. The role of citizen science in addressing local environmental issues

Karumanthra, Arya; Indiana University. A Correlational Study of Inservice Teachers' Global Competency and Science-Teaching Self-Efficacy

Moga, Collins; University of Massachusetts. Perceptions of 10th Grade Multilingual Learners About Supports in Learning Science: A Phenomenographic Study

Monteiro, Mariana; University of São Paulo (Brazil). Understandings of Social Practices of Science and evaluating information by high school students

Pearcy, Melissa; Washington State University. Capturing Elementary Science Specialists' Beliefs About Teaching and Learning Science: A Comparative Case Study

Poor, Sarah; Texas A&M University. Factors Associated with College Students' Navigation of Science Misinformation

Schafer, George; Drexel University. Unearthing CROPS: A Systematic Literature review of Community-based, Reciprocal, Out-of-school Programs in STEM (CROPS)

Seng, Sopheak; Purdue University. A Systematic Review of Design Fixation at K-16 Engineering Education

Shackley, Mathew; University of California, Santa Barbara. Developing prospective science teachers' epistemic orientations toward teaching for knowledge generation and civic science education

Soni, Ruchi; Florida International University. Exploring Elementary Pre-Service Teachers' Science Teaching Efficacy Beliefs and Anxiety at a Hispanic Serving Institution

Squillace Stenlund, Kristine; University of Minnesota- Twin Cities . 2-Year College Faculty Perspectives on Sensemaking Instruction of Mathematics in Biology

Titus, Ashley; Texas Christian University. Socio-scientific based community science and the role on undergraduate self-efficacy

Torralba, Maria Veronica; De La Salle University, Philippines. Development of Learning Progression for Evaluating Arguments Situated in Secondary Physics Instruction of Classical Mechanics

Tukurah, Grace; Michigan State University. Natural Hair Care as a Domain of a Scientific Community of Practice

Zohery, Vivian; University of Maryland- College Park. Participatory Action Research with Undergraduate Muslim Women in STEM fields

Strand 1: Science Learning: Development of student understanding
Related Paper Set
The Value of Cognitive Linguistics for the Design of Fruitful Learning Environments in Biology Education
20-Mar-24, 9:15 AM-10:45 AM
Location: Plaza Court 2

Quo Vadis – Learning Progressions in the Context of the Conceptual Metaphor Theory
Denis Messig*, Department of Science Education, Germany
Jorge Gross, Department of Science Education, Germany

ABSTRACT
Photosynthesis and experimentation to concerning NOS are difficult issues teachers are confronted with in science classes. This can be due to alternative conceptions students hold, which are often contrary to their scientific counterparts. To create fruitful learning environments, it is seen to be highly important to take learners' alternative conceptions into account and analyze the specific learning pathways. Such models of subject-specific learning processes have been published under the generic term "learning progression" since the 2000s, especially in the USA. But what are the core ideas of learning progressions and how can they be presented? To identify students' conceptions and the interventions' impact, two qualitative case studies (videotaped high-school students n=12 and n=57) were conducted and high-school students' pre-instructional conceptions were identified empirically to maintain the learning pathways. The learning processes and signs of conceptual change were identified using Qualitative Content Analysis (Mayring, 2004). Finally, a cognitive-linguistic analysis using Conceptual Metaphor Theory was conducted (Lakoff & Johnson, 2008). Interestingly, underlying embodied conceptions and image schemas about human nutrition and experimentation became evident. These thinking patterns were used metaphorically and, therefore, can be seen as the basis to understand the learning pathways of students.

Understanding Student Conceptions About Cell Membranes
Leonie Johann, Nord University, Norway
Jorge Groß*, Leibniz Universität Hannover, Germany
Fredrik Rusk, Åbo Akademi University, Finland

ABSTRACT
Framed by the Model of Educational Reconstruction and Conceptual Metaphor theory, this study qualitatively identifies and explores student conceptions about cell membrane biology (CMB). Sound knowledge of cell membrane biology plays, for example, a critical role in the medical field to develop drugs for the treatment of diseases such as HIV; it also impacts individual lifestyle choices, such as the acceptance or rejection of vaccinations. Therefore, this study aims to discuss how CMB can be made more accessible for upper-secondary teaching and learning. To collect student conceptions about CMB, we conducted video-documented semi-structured individual interviews with nine Norwegian upper secondary students, aged

17-18. To identify and understand the experiential genesis of student conceptions, we analyzed the students' statements via qualitative content analysis linked to cognitive-linguistic analysis. We found that students hold three core ideas about CMB; one is that cell membranes are static barriers existing to protect the inside of cells. We argue that these ideas might cause misunderstandings during learning CMB because they might hamper students' consideration and understanding of dynamic molecular processes causing cell membrane function. To avoid these misunderstandings, we propose content and learning goals, specially designed for upper-secondary biology courses.

The Benefit of Moral Metaphors for Fostering Decision-Making Competence in the Field of Animal Ethics

Nadine Tramowsky*, University of Education Freiburg, Germany

ABSTRACT

Conceptual Metaphor Theory (CMT) is employed in educational research to analyze students' language and their use of conceptual metaphors. Previous studies have focused on scientific teaching, emphasizing the importance of students' conceptions for conceptual change. However, there's limited research on moral metaphors in science education. This study explores the structure of moral conceptions to stimulate discussions on morality and socio-scientific topics. We conducted a qualitative case study to identify German high-school students' moral conceptions and metaphors regarding animal ethics and to develop a tool for analyzing these. Students were questioned in guided interviews and videotaped teaching experiments (N=21). Conceptions were identified through qualitative content analysis, followed by a cognitive-linguistic analysis using CMT. Findings reveal underlying embodied conceptions and image schemas tied to human well-being. When deciding on animal ethics, students prioritize their own well-being and express moral conceptions via embodied concepts. They view animal-human relationships predominantly hierarchically. Embodied conceptions persist, but we aim to expand and reflect on them rather than erasing. Teaching experiment results show that reconstructed interventions stimulate perspective change in students. This research can foster reflection and expansion of students' perspectives in educational environments.

Peer Interaction - Tracking Conceptual Transformation in Collaborative Learning Environments

Malte Michelsen*, Leibniz Universität Hannover, Germany
Jorge Groß, Leibniz Universität Hannover, Germany

ABSTRACT

Dealing with student conceptions is a central element of student-oriented teaching. However, the implications for lesson design have not yet been fully elucidated. Approaches, such as the conceptual change theory, have over the years been supplemented by affective and motivational factors. Little is known about the mechanism linking these factors. This qualitative study aims to shed light on the process of conceptual transformation. Therefore, learners were given an assignment on the topic of plant nutrition and the task of collaborating to develop a jointly supported solution. To study changes in conceptions, the

Peer-Interaction-Method (PIM) was used. It requires learners with different conceptions to collaborate to cause a content-related conflict. The expressions of the participants were examined using the CMT. The results were unexpected: the anticipated content-related confrontations do not have to occur to reach a jointly supported solution. Instead, we can show that a social conflict shapes the collaboration process. Furthermore, the peer interaction method turns out to be a constructive way of dealing with subject-specific heterogeneity in conceptions. To provide the necessary infrastructure for the matching of learners with different conceptions in the school context, we developed a digital plug-in for Moodle e-learning platforms.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
Undergraduate Pedagogy and Practices
20-Mar-24, 9:15 AM-10:45 AM
Location: Plaza Court 5

What is a Geoscientist? Uncovering Conceptual Profiles in Undergraduate Student Drawings
William Romine*, Wright State University, USA
Deepika Menon, University of Nebraska, USA
Peggy McNeal, Towson University, USA

ABSTRACT
The "Draw a Scientist" task has been used for approximately 40 years but application in undergraduate geoscience contexts is limited. In this study, we apply a "Draw an Earth Scientist" task to better understand (1) the students who enter our undergraduate geoscience courses and the conceptions about the geoscience profession that they hold, and (2) how those conceptions change after the geoscience coursework. This was administered as a pre- and post-test before and after the course to 94 participants enrolled in introductory geoscience courses at two large public universities. Latent Class Analysis was used to uncover conceptual profiles in students' drawings. We found 3 classes (entropy = 0.997) of drawings: (1) portraying an Earth scientist as the "general scientist" indicated in popular culture (wearing a lab coat and glasses, and working indoors in a lab), (2) portraying an Earth scientist as a scientist who works outdoors and works with data, and sometimes is interested in rocks, and (3) portraying unclear or mythical conceptions of Earth scientists. Our data show that undergraduate geoscience coursework is effective in reducing "general scientist" conceptions of what work in the Earth sciences entails.

Undergraduate Virtual Mentorship in Support of K-12 Science Inquiry Practices
Alex St. Louis*, Augusta University, USA

ABSTRACT
This grounded theory qualitative study investigates the experiences of undergraduate and K-12 students participating in a semester-long authentic scientific research project. The

undergraduate students serve as virtual mentors of a scientific research project to support the development of successful inquiry skills in K-12 students. I report on the undergraduate mentorship experience (elements of engagement, feedback, use of technology, and personal reflections) and the K-12 students' development of scientific inquiry skills, defined as six NGSS Science and Engineering Practices: asking questions and defining problems, planning and carrying out investigations, analyzing and interpreting data, using mathematics and computational thinking, engaging in argument from evidence, and obtaining, evaluating, and communicating information. The data shows that undergraduates develop different mentoring competencies based on their previous experiences with mentorship and research, and I suggest best practices for developing mentorship in the sciences. Additionally, I report the K-12 students successfully developed the six measured Science and Engineering Practices after completing their research projects. This study shows that virtual mentorship of scientific research positively influences students in K-16 education through developing mentorship/teaching, research, and inquiry skills.

Can I Kick It: The Evolution of University Students' Pedagogical Practices in a Sneaker Lab

Kareem Edouard*, Drexel University, USA
Sinead Meehan, Drexel University, USA

ABSTRACT

Informal science, technology, engineering, and mathematics (STEM) learning environments provide valuable opportunities to positively influence the development of K-12 students' STEAM interests, knowledge, skills, and identities. In an effort to provide culturally relevant STEAM programming to diverse groups of participants, two students at a private research university developed a 3-day STEAM Kicks pilot program aimed at promoting computational making and STEAM identities through the process of sneaker design and manufacturing. Design features of the STEAM Kicks program and the STEAM lab where the program took place included a flexible learning environment, multi-modal technology integration, authentic learning contexts, and hand-ons, experiential learning. This study examined shifts in the informal STEM educators pedagogical practices between the first and second implementation of the pilot program. Data sources included video observations, photographs, research field notes, and the university students' reflective journals. Findings showed that through the iterative cycle of experiential learning, the university students were able build a repertoire of pedagogical knowledge and skills, which allowed them to engage more flexibly and effectively with the second group of participants as compared to the first. Recommendations for future research on informal STEM learning programs and the development of informal STEM educators pedagogical practices are discussed.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set
Science Teacher Learning
20-Mar-24, 9:15 AM-10:45 AM
Location: Plaza Court 3

Scaffolding Elementary Students' Scientific Evaluations of Model-Evidence Relationships About Fossils
Timothy Klavon*, Black Hills State University, USA
Sydney Haugland, Black Hills State University, USA
Nancy Gans, University of Maryland, USA
Melissa Schwiesow, Black Hills State University, USA

ABSTRACT
Model-Evidence Link Diagrams (MELs) have been developed for secondary students to scaffold the relationship between explanatory models and lines of evidence. MELs engage students' plausibility judgements about competing models and, by allowing for students to re-appraise these judgements, they learn more deeply about the given topic. This pilot study seeks to develop MELs for elementary students about how scientists use fossils to model past Earth environments. We have created a MEL that includes an expository fictional story and interactive worksheet to make MELs accessible for elementary students. The students showed large post-instructional knowledge gains (p<.001, _2=0.455) and large delayed post-instructional knowledge gains (p<.001, _2=0.467). Structural equation modeling (SEM) indicates that the students' levels of scientific evaluation have a small effect on their post-instruction plausibility (_=0.14, p=.05, _2=0.035). However, pre-instructional knowledge had much larger effects for post-instructional knowledge gains (_=0.38, p=.25, _2=0.141) and delayed post-instructional knowledge gains (_=.044, p<.01, _2=0.212). These findings are encouraging as students are learning and retaining knowledge about fossils' role in scientific understanding of past Earth environments. The SEM indicates that we need to continue to refine the instruments to engage the plausibility judgements more effectively.

A Case of Preservice Elementary Teachers Making Meaning Through Modeling Practices
Ayça Fackler*, The University of Missouri, USA

ABSTRACT
Learning science requires students to use multiple linguistic resources in addition to scientific language in meaning-making. Multimodal modeling practices have the potential to enhance students' meaning-making experience through constant shifts in meanings. Grounded in the Semantics dimension of the Legitimation Code Theory (LCT), this case study examined how multimodal modeling can facilitate packing and unpacking meanings while learning science ideas. Data sources were audio and video recordings that captured the modeling instruction and student interviews along with student artifacts. A combination of Multimodal Interaction Analysis and LCT analysis suggested that students pack and unpack

meanings while learning science ideas with multimodal modeling practices by engaging with materials to initiate packing meanings, generating and employing different modalities, and unpacking meanings through diverse modalities.

Examining Influences on Elementary Teachers' Transfer of Learning from a Science Professional Development Program

Andrea Phillips*, Indiana University, USA
Meredith Park Rogers, Indiana University, USA

ABSTRACT

This study examines the role of science teaching orientations and emotions on teachers' transfer of learning from a PD into their practice once the supports of the PD have been removed. Employing an actor-oriented stance to examining transfer in teachers' practice, data sources include interviews, audio-recorded reflections based on a protocol provided to the teachers, and video recordings of 3-4 lessons from a science unit. Findings show that orientation alignment, especially in tandem with positive emotion, facilitated transfer to practice. As teachers experienced positive emotion in anticipation of a teaching practice that was in alignment with their orientation, they were better able to transfer it to practice. Barriers to transfer included perceived orientation misalignment, negative emotion, and time constraints. The implications of this study lie in how to address teachers' orientations and emotions in the context of professional development to help facilitate successful long-term transfer.

Fostering Pedagogical Judgment in Novice Elementary Science Teachers

Christopher Mangogna*, University of Washington, USA

ABSTRACT

In science education, novice elementary teachers navigate systemic approaches to status quo instruction that are often race-neutral or rooted in environmental racism (Beltrán et al., 2016). However, for students to see their identity in science, teachers need a cognitive shift to challenge their instruction to be culturally ambitious. This study uses a sociocultural learning lens to examine how two novice elementary teachers' pedagogical judgment (action, reasoning, and responsibility) development towards culturally ambitious science is supported. For analysis, a conceptual framework and a variety of mix-methods are used to create coding schemes for a systematic and interdisciplinary analysis that captures the sociocultural interactions of these teachers' learning. The analysis revealed a strong connection to Communities of Practice, agency, and curriculum. Community of Practice strongly influences pedagogical judgment development as it establishes an environment and platform to learn; agency serves as a catalyst for moving the pedagogical development framework; and curriculum emerges as a pivotal bridge for entry into teachers' pedagogical judgment development. Ultimately, the study advocates for a transformative shift towards equitable and inclusive science education. It accomplishes this by encouraging novice elementary teachers' development in implementing culturally-ambitious science instruction that affirms all student identities.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set
Learning science with families
20-Mar-24, 9:15 AM-10:45 AM
Location: Governor's Square 11

The Interplay between Interest Development, Conceptual Change, Affect, and Agency in Everyday Family Science Interactions

Irit Vivante*, Ben Gurion University of the Negev, Israel
Dana Vedder-Weiss*, Ben Gurion University of the Negev, Israel

ABSTRACT
Interest is critical for science learning and families play a major role in supporting their children's interest in their everyday routines. Therefore, this study aims to examine how science interest develops in everyday family life. Through a two-year insider researcher-ethnography of one family, we collected video and audio recordings of science-related interactions across settings using fixed 24/7 cameras in the house and Go-Pro cameras at the outdoors. Screening content logs of 397 recorded science-interest events, we selected an illuminating case study of one particularly rich interest development process. The case consisted of eight events across five months, in which Eyal (3 years old) exhibited an interest in the circulatory system. We used interaction analysis to identify expressions of interest, affect, agency, and conceptual change within and across the eight events, and to examine the interplay between them. The analysis demonstrated how interest generated agency, and consequently, conceptual change, as well as how this conceptual change reignited interest. It further showed how affect supported the maintenance and development of interest, but was also shaped by the learning that stemmed from this interest. The findings contribute to the literature of science interest and to the field of learning in informal environments.

Capturing Family Engagement during an At-Home STEM Intervention

Kristie Gutierrez*, Old Dominion University, USA
Margaret Blanchard*, NC State University, USA
Kylie Swanson*, University of Colorado Colorado Springs, USA

ABSTRACT
At-home parental involvement in their child's learning could be key to greater STEM engagement, increased learning, and planning for post-secondary education and careers. This qualitative exploratory case study investigates the experiences of three middle school students and their families who participated in STEM Career Club: Home Edition over a 10-month period. Two frameworks informed this research study: the Learning Dimensions of Making and Tinkering framework was used to help notice and document the ways in which families interacted during STEM activities that were explicitly designed for family engagement within the home, and the Hoover-Dempsey and Sandler (HDS) Model of Parental Involvement was used to explore the ways in which parents were involved in their child[ren]'s STEM learning at home. The percentages of the various Learning Dimensions

evidenced in the audio recordings differed by activity type (e.g., engineering-focused, biology-focused). Overall, family interview data was more often coded within the HDS Model for Level 1 on Motivators for Parental Involvement, particularly in the area of Family Life Context Variables. Findings from this study can be utilized by informal (and formal) STEM educators as they plan activities for families in informal contexts (e.g., homes, museums, clubs, parks).

Science Identity Work and Persistence from an Intensive Family Workshop Series

Debbie Siegel*, Institute for Learning Innovation, USA
Scott Byrd*, Medomak Consulting Group, USA
Elysa Corin, Institute for Learning Innovation, USA

ABSTRACT

This research project focuses on understanding the immediate and long-term impacts of an intensive workshop series for rural families with youth aged 8-11 years old at two science museums. Families spent six hours on six Saturdays with their children learning about wildlife and marine ecology. Our research focuses on how youth and family science identity work is constructed within and beyond the workshops ultimately supporting family persistence in science. Through survey and interview analysis we found two broad themes related to the building of science identities and persistence. First, through these intensive workshops families, including youth, develop science identities directly as well as broader, more accessible views of science and scientists. The design of the programming around families rather than just youth pointed to the important role of family learning in shaping youth science learning, identity, and participation. And, second, that families and youth begin viewing science as all around them and not just in the lab. There was an increase in their own sense of science identity and confidence as someone who knows about and can engage in science. They benefited from being scientists, using scientific tools, and meeting different types of science professionals.

Paseos and Outdoor School: Developing Latina/o/x Families' Interest and expertise in the outdoors.

Diana Crespo-Camacho*, Oregon State University, USA

ABSTRACT

Because Latina/o/x students and other minoritized students now have the opportunity to attend an outdoor education experience for the first time, there is a need to understand these participants' learning experiences and consider supports that might enhance those learning experiences. Also, empirical research related to the experience of minoritized youth/communities in outdoor/science education is limited (Browne et al., 2019; Montero et al., 2018; Paisley et al., 2014; Roberts et al., 2015).
A qualitative study of family field trips prior to the outdoor education experience was conducted to gain an in-depth understanding of the value of experiential outdoor science learning opportunities for Latino/a/x fifth-grade students and their families. Primary data for the study were collected during a planning meeting and three paseos with families in natural areas in a state in the Pacific Northwest. Data included platicas, participant

observation, dialogic inquiry, and photovoice. Additional data were collected during a three-day outdoor education program for 5th-grade students in the Spring of 2022 through observation and contextual notetaking. Finally, a focus group interview was conducted during a family event where students who participated in the outdoor education program and the paseos shared their experiences with their families.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Reflective Practice to Support Teaching and Learning
20-Mar-24, 9:15 AM-10:45 AM
Location: Plaza Court 4

Reflective Practice-Driven Pre-Service Teachers Develop Science and Engineering Lesson
Tharuesean Prasoplarb*, Kasetsart University, Thailand
Chatree Faikhamta, Kasetsart University, Thailand

ABSTRACT
The preparatory of pre-service teacher to teach STEM become a big challenge with training them to be the STEM lesson designer, not just only duplicate the previous STEM activity. To understand about science and engineering practice and develop lesson plans might not give them sufficient experience. The Interactive-Constructive-Active-Passive science and engineering practices (ICAP SEPs) framework was adapted to visualize how pre-service teachers (PSTs) reach each nature of the SEPs learning activity throughout their micro-teaching experience. In this study, 18 PSTs were assigned to teach two SEPs in one learning activity, then conduct their own teaching reflection session with four kinds of reflection (-in; -on; -for; and -as -action). All data were collected from all sessions and analyzed using content analysis. The results indicate that reflection-on-action could improve their ability to teach individual SEP. However, reflection-as-action helped them meaningfully connect between two SEPs, while reflection-for-action access to PST's belief about managing classrooms with equity.

Elementary Teacher Candidates' Reflection on Their Roles as Educators After Engaging in a Digital Simulation.
Zoubeida Dagher*, University of Delaware, USA
Christy Metzger, University of Delaware, USA

ABSTRACT
This study analyzes elementary preservice teachers' (PST) reflection on their roles as educators following their engagement in an equity-oriented digital simulation in the context of a science methods course. Using the Teacher Moments' open access digital platform, 111 PSTs participated in the simulation, To Intervene or not, pertaining to the case of two students from historically minoritized communities to improve their engagement in 4th grade science. After proposing interventions and justifying them, PSTs were prompted to reflect on their roles as teachers. A qualitative analysis of PSTs' reflections showed that the

majority expressed an ethic of care in which they saw themselves as responsible for the well-being and success of all students, while a smaller number focused on simply providing the resources the students needed. Furthermore, some PSTs used emergent metaphors that gave additional insight into their thoughts and motivations. Implications for using simulations in teacher education to enhance PSTs disposition to engage in equitable teaching practices are discussed.

Strand 8: In-service Science Teacher Education
Symposium
A Symposium Applying Conjecture Mapping to Learn From Design Tensions in Curriculum-Based Professional Learning
20-Mar-24, 9:15 AM-10:45 AM
Location: Governor's Square 14

A Symposium Applying Conjecture Mapping to Learn From Design Tensions in Curriculum-Based Professional Learning

Cynthia Passmore*, University of California, Davis, USA
Stina Krist*, University of Illinois, USA
Jason Buell*, Northwestern University, USA
Chris Griesemer*, University of California, Davis, USA
Barbara Hug*, University of Illinois, USA
Katerine McNeill*, katherine.mcneill@bc.edu, USA
Sean Smith, Horizon Research, USA
Brian Reiser*, Northwestern University, USA

ABSTRACT
Curriculum-based professional learning (CBPL) is a critical component of the implementation of the Next Generation Science Standards (NGSS). CBPL provides teachers with opportunities to learn about the NGSS and how to use high-quality instructional materials (HQIM) to support student learning. However, CBPL can be challenging to design and implement effectively. One of the key challenges is managing the tension between the immediate needs of teachers and the longer-term goal of supporting pedagogical change. Teachers need to learn how to use HQIM effectively on a day-to-day basis, but they also need to develop a deep understanding of the NGSS and how to support student sensemaking. This symposium will apply conjecture mapping to learn from design tensions in CBPL. Conjecture mapping is a method for making explicit the connections between design decisions, mediating processes, and intended outcomes. We have crafted our symposium to engage participants in a deep look at some of the common designs that occur across contexts. We hope to create the conditions for members of the NARST community who are engaged in CBPL to come together to compare ideas and push one another into ever more deeply considered designs.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Enacting Social Justice Focused Science and STEM Learning
20-Mar-24, 9:15 AM-10:45 AM
Location: Governor's Square 12

Transforming STEM Education: Co-creating Educator Critical Identities through Social Justice and Culturally Sustaining Pedagogies
Karla Hale*, Western Oregon University, USA
Cory Buxton, Oregon State University, USA
Felisha Dake, Oregon State University, USA
Melissa Livingston, Oregon State University, USA

ABSTRACT
Despite efforts and funding, inclusiveness in STEM classrooms in the U.S. remains a challenge. This study investigates how co-creating professional learning with K-12 educators promotes inclusiveness in STEM and extends science education beyond traditional boundaries to address socio-scientific issues. Using design-based research, we explored how critical educator identities develop and support educators' efforts to inspire students' aspirations and success in STEM pathways.
We introduce the Critical Identities for STEM Teachers (CIST) framework, emphasizing the link between science knowledge, identity, and social justice. The study focuses on 43 educators running 37 after-school STEM clubs across mostly rural and remote areas of the state. Methods included quantitative and qualitative analysis of data from surveys, focus groups, and logs. Comparative case studies provided detailed insights into educators' learning stories.
The findings support four design principles aligned with CIST. These principles involve grounding STEM in culturally sustaining and social justice practices, offering educators a multiplicity of context-specific opportunities for enactment and reflection, and promoting critical awareness of systemic equity issues. These principles may be useful when planning STEM professional learning with pre- and in-service educators to establish more inclusive STEM K-12 spaces and prepare them to address relevant societal issues.

Core to What? Novice STEM Teachers' Perceptions of Antiracist and Socially Just Core Teaching Practices
Rachael Gordon*, University of Michigan, USA

ABSTRACT
Given a recent decline in teacher education enrollment and increased teacher attrition, there is a critical need to both develop and retain high quality educators, particularly in areas with our nation's most vulnerable youth. Research demonstrates that teachers who are more effective are more likely to stay, even in under-resourced areas, suggesting the need for better prepared teachers in more challenging school spaces. STEM educator preparation is faced with a challenge of not only populating classrooms but doing so with individuals who

are prepared and supported to provide high quality antiracist and socially just (ARSJ) STEM learning opportunities for all students. This study explores two cases of novice STEM teacher learning as they develop ARSJ core teaching practices, and work to become ARSJ practitioners, within a teacher education reform model that makes use of extended, embedded, and place-based supports. Utilizing ethnographic design-based research methods and drawing on sociocultural learning theories, findings suggest that participants' perceptions of STEM content connections to ARSJ core teaching practices varied across participant and manifested differently within their respective practice. Both participants experienced challenges and possibilities in becoming ARSJ STEM teachers. This study has implications for STEM teacher education design towards ARSJ aims.

Describing Teachers' Everyday Efforts to Enact Social Justice Teaching in Their Science Classrooms

Jarod Kawasaki*, California State University, Dominguez Hills, USA
Sandy Chang, University of California, Los Angeles, USA

ABSTRACT

Social justice-oriented teacher preparation programs infuse critical theories and pedagogies in their coursework to build teachers' capacity to design and enact teaching that seeks to disrupt systemic oppression and injustice. Program graduates often seek teaching positions in schools that serve working class communities of color with the goal of working alongside students, families, and the community to act as agents of change. Yet, little is known about the everyday practices that they use during their first few years of teaching to enact the social justice theories and pedagogies they learned from their teacher preparation program. We report on interviews conducted with 20 early career science teachers (i.e., 1-5 years of teaching experience) that shared the social justice strategies, lessons, and activities they used in their classroom. We found that teachers described a multitude of teaching practices that depicted their everyday pursuit of social justice in their science classrooms, yet also shed light on the challenges that these teachers experienced in their early years of teaching.

"Making the Invisible, Visible!": Visualizing Science and Social Justice through Modeling

Marisa Ritchie*, California Polytechnic State University, USA
Spencer Paine*, California Polytechnic State University, USA
Christina Fuller*, California Polytechnic State University, USA
Jasmine Nation*, California Polytechnic State University, USA
Kurt Holland*, California Polytechnic State University, USA

ABSTRACT

Modern science teaching strategies emphasize active sensemaking and position students as scientists, while critical scholars simultaneously advocate for pedagogies that embrace diverse cultural and linguistic assets. The value of both these approaches is broadly recognized, however, they are difficult for educators to implement. Therefore, we investigated a week-long professional development (PD) about how modeling can help bridge these gaps, encouraging equity and critical thinking. We utilized the Critical and Cultural Approach to Ambitious Science Teaching, plus a design-based research approach to

analyze PD artifacts and surveys from 56 in-service K-12 educators. We compared how elementary, middle, and high school teachers viewed modeling in science differently, how these views shifted throughout the PD, and how they viewed modeling in relation to social justice. Our findings reveal how teachers began to see modeling as dynamic, student-driven, and personally relevant. We also documented the significance of context-rich phenomena, where real-world issues became entry points for both science learning and social justice engagement. In the full paper, we also include findings from classroom implementation, and we hope drawing on program processes and design decisions can help encourage more teachers to model in ways that are academically rigorous and inclusive.

Strand 10: Curriculum and Assessment
Symposium
Measuring Computational Thinking in Non-Programming Contexts: Progress and Challenges
20-Mar-24, 9:15 AM-10:45 AM
Location: Plaza Court 6

Measuring Computational Thinking in Non-Programming Contexts: Progress and Challenges

Eben Witherspoon*, American Institutes for Research, USA
Jonathan Margolin, American Institutes for Research, USA
Dorothy Bennett*, New York Hall of Science, USA
Ibrahim Dahlstrom-Hakki*, TERC, USA
Jessica Bailey*, EDC, USA
Jackie DeLisi, EDC, USA
Emily Relkin, EDC, USA
Leiny Garcia*, WestEd, USA
Yvonne Kao, WestEd, USA
Arif Rachmatullah, SRI, USA

ABSTRACT
The Next Generation Science Standards identifies computational thinking as a scientific practice that is essential for science and engineering curricula. However, assessing students' understanding and skills in computational thinking outside of a programming context has proven challenging. This interactive symposium session will share progress and challenges from six research projects' efforts in the design, development, and use of measures of K-12 students' computational thinking knowledge and skills across multiple science, engineering, technology, and mathematics disciplines. All projects have a shared focus on developing or selecting computational thinking assessment instruments for students who may not have prior knowledge of specific programming languages and tools. Each team will summarize their choice of computational thinking framework, development method, and modality, and then participate in a panel discussion about challenges faced and the team's responses to those challenges, followed by a Q&A period. Topics for discussion will include the role of context and curriculum in influencing development of measures, measure validation

procedures, and the extent to which the measure could be used with different student populations, particularly those who have been underrepresented in science.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Supporting Agency, Access, and Community Building: From Middle School to Graduate School
20-Mar-24, 9:15 AM-10:45 AM
Location: Governor's Square 17

STEM ACCESS: Conceptualizing a University-School Partnership Model to Engineer Justice in STEM Education
Meredith Kier*, William & Mary, USA
Lindy Johnson, William & Mary, USA

ABSTRACT
We introduce a conceptual model for a school-community partnership that partners STEM undergraduates of color with middle school science and mathematics teachers, to provide culturally relevant STEM learning experiences for historically marginalized youth. The model is grounded in sociocultural, Critical, and design-based and is informed by three years of implementation in a large urban school district. We draw on various data sources, including interviews, field notes, focus groups, and surveys. The model emphasizes the importance of positioning undergraduates of color as brokers who can help to engineer justice in STEM education by providing critical and creative adaptations to the curriculum and centering the stories and perspectives of middle school youth. We emphasize the role that storytelling can play in facilitating culturally relevant practices between stakeholders to center the voices of students. Undergraduates can be critical stakeholders in communicating practices that promote equity in STEM classrooms.

Student Agency in Science Education: Navigating Structures for Inclusivity and Empowerment
Danielle Malone*, Washington State University, USA
Judith Morrison, Washington State University, USA

ABSTRACT
This research explores the role of student agency within a twelve-week Earth science classroom, investigating its interplay with classroom structures. Rooted in recent scholarly attention, the study seeks to address the divide between classroom science and students' experiences while confronting ongoing educational inequities. Drawing from sociological and philosophical theories, the research examines how student agency and structures intersect, shaping the landscape of science teaching and learning. Through a case study within a high school Earth Science class, the investigation illuminates how students navigate structural constraints to assert agency and advocate for themselves and their peers. The findings reveal the diverse manifestations of agency, challenging traditional notions of

academic success by showcasing how agency and performance intertwine. In particular, the research highlights instances where students demonstrate self-advocacy and exhibit advocacy for others to reshape classroom dynamics and enhance their learning experiences. By recognizing the nuanced forms of agency, educators can reimagine teaching approaches, creating inclusive learning environments that honor individual strengths and backgrounds. The study contributes to the evolving landscape of science education by fostering innovative teaching strategies that embrace student agency as a driving force for meaningful change.

Conceptualizing a Slow-Science Approach to Fieldwork

Rie Malm*, University of Copenhagen, Denmark
Sriparna Saha, University of Colorado Boulder, USA
Lisa Corwin, University of Colorado Boulder, USA
Ben Kennedy, University of Canterbury, New Zealand

ABSTRACT

Transdisciplinary collaborations between field, theory, laboratory and computer-based scientists can lead to novel solutions and mitigation of large scale and complex environmental challenges. However, under-representation of Indigenous and persons excluded due to ethnicities and Race (PEER) students in STEM disciplines such as ecology and geology continues to be a persistent issue. The present-day research environment that pushes for quantity over quality exacerbates existing equity issues influencing these groups of people. In field intensive disciplines, this fast-paced culture has further implications for teaching quality, and in turn equity and inclusivity, for all. By neglecting the time needed to effectively engage in inclusive, equitable practices, fast-paced field cultures reproduce the exclusionary environments that make it difficult for some students to continue to participate in fieldwork and become disciplinary experts. In this proposal, we conceptualize a slow science framework specifically for undergraduate field based disciplines that can foster a more diverse, healthy and collaborative academic culture that allows hesitation, exploration, failure, and connection. We further discuss implications for teaching and learning in the field and higher education.

Role of Field Experiences and Student Identities in Community Building in EBIO Graduate Students

Sriparna Saha*, University of Colorado, USA
Lisa Corwin, University of Colorado, USA
Nancy Emery, University of Colorado, USA
Scott Taylor, University of Colorado, USA
Julian Resasco, University of Colorado, USA
Sandhya Krishnan, University of Colorado, USA
Valerie Mckenzie, University of Colorado, USA

ABSTRACT

Successful collaborations are significant in Ecology and Geology, where scientists work across complex, large-scale, multifaceted problems. However, many graduate programs in the United States risk the loss of PEER (Persons Excluded due to Ethnicities and Race) due to a

lack of intentional community building that supports collaborative research endeavors, indicated by the low diversity in the fields above. We draw from evaluating a novel graduate program at a large public university in the western United States with an immersive field component to highlight factors influencing the retention of PEER students. In 2022, incoming graduate students spent four weeks at a Research Station and partnered with faculty and peers to collect ecological and environmental data using different techniques. We conducted a mixed-methods study which included surveys and interviews to understand how the efficacy of programmatic elements differs across student identities. Inductive coding of interview data indicates three specific cases where the interaction of student identities with the program components leads to differences in individual experiences. We also note that all students identified community building as a crucial component of their graduate school experience. Thus, the intentional design of field experiences can help increase PEER students' retention in graduate programs.

Strand 12: Technology for Teaching, Learning, and Research
Symposium
Natural Language Processing in Science Teaching and Learning
20-Mar-24, 9:15 AM-10:45 AM
Location: Governor's Square 16

Natural Language Processing in Science Teaching and Learning
Mei-Hung Chiu*, National Taiwan Normal University, Taiwan
Mao-Ren Zeng*, National Taiwan Normal University, Taiwan
Ching-Sui Hung*, National Taiwan Normal University, Taiwan
Hsin-Kai Wu, National Taiwan Normal University, Taiwan
Ren-Cheng Zhang*, National Taiwan Normal University, Taiwan
I-Chien Chen*, Michigan State University, USA

ABSTRACT
Text-as-data approaches play an essential role in the teaching and learning process as they can reveal discipline knowledge, practices, emotionality, and actions in the form of written texts. New computational techniques and machine learning have expanded our research toolkits. We propose a symposium using text-based analyses and Natural language processing (NLP) to uncover the latent themes, topics, sentiments, evidence, and discipline ideas in the textbooks to gain data insights in the educational setting. The contribution of this section is to demonstrate the applications of these text analytics to enhance the practical work of teaching and learning and further explore feasible, desirable, and viable solutions for challenges in converting qualitative data into quantitative analysis. The first paper explores two textbooks' co-occurrence of scientific concept words. The second paper examines the connection between the rubrics design and student responses for automated scoring preparation. The third paper investigates the unsupervised classification of Implementing inquiry-based science instruction teaching goals and its comparison to the national curriculum guidelines. The fourth paper investigates kindergarteners' sentiments in conversations across various scientific practices and residential areas. The fifth paper explores

the predictive concurrence of word bi-gram from teacher-to-student actions in cognitive and affective practices.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set
Socioscientific Reasoning and Perspective Taking
20-Mar-24, 9:15 AM-10:45 AM
Location: Plaza Court 8

Enhancing Undergraduate Students' Socioscientific Reasoning and Addressing Misconceptions through Internationalized Climate Change Instruction
Conghui Liu*, Indiana University Bloomington, USA
Shukufe Rahman*, Indiana University Bloomington, USA
Gayle Buck, Indiana University Bloomington, USA

ABSTRACT
Climate change is a socioscientific issue that embeds scientific content, process, and complex social aspects. Discussions of this issue are often related to controversial, ill-structured problems that lack clear-cut solutions. A student's understanding of the content knowledge and the reasoning skills, increasingly referred to as socioscientific reasoning, are important considerations within climate change instruction. This design-based research focused on refining internationalizing climate change instruction to enhance undergraduate students' understanding of this global issue and promote students' socioscientific reasoning in an undergraduate inquiry-based environmental science course over three iterations. Results from each iteration indicated refinements for subsequent implementations. Final results illustrate the effectiveness of internationalizing instruction on climate change in this rich information context. This study also explored the possibility of bringing global realities to the classroom to address misconceptions about climate change and support the practice of reasoning skills. Results further indicate a lack of skepticism and inquiry among undergraduate students when negotiating with socio-scientific issues, which leads to the need for further study.

Promoting Functional Scientific Literacy Through Community Service: Implications for Curriculum Development in Secondary Environmental Education
Emily Little*, Georgia State University, USA
Renee Schwartz, Georgia State University, USA

ABSTRACT
This study investigates the relationship between environmental identity (EI), nature of science (NOS), and socioscientific issues (SSI) using a community service project embedded in a high-school environmental science curriculum to answer the overall question: How do students demonstrate functional environmental scientific literacy through their decision making when addressing socioscientific issues within their community? Thematic analysis revealed one's intrinsic or extrinsic connection with nature played a significant role in

addressing SSI within their community. These students also drew on their understanding of observations and inferences, as well as the empirical and socio-cultural NOS in their research and in the design and implementation of their service initiatives to educate community members on the environmental, social, and economic ramifications of these socioscientific issues. Notable for NOS connections is the attention to socio-cultural aspects of their SSIs, including social justice issues regarding working conditions and labor laws, as well as political, economic, religious and cultural aspects that influence funding, access to resources, and education. EI is a fundamental component of functional scientific literacy and can be used to empower students to engage in SSI-based environmental issues that have personal meaning while also providing contextualized opportunities to apply their NOS understanding.

Erasure of Socioecological Violence in Science Education
Ajay Sharma*, University of Georgia, USA
SungEun Min, Kutztown University of Pennsylvania, USA

ABSTRACT
The world is rife with socioecological violence. Thus, one should expect science education to enable students to have a better understanding of the socioecological violence unleashed on the underprivileged on account of socioecological disruptions in the world. Our study uses critical discourse analysis to explore the discursive representation of socioecological violence in official school science discourse as represented in three officially mandated environmental science textbooks in Florida, United States. The findings suggest that the official school science discourse may not be offering discursive resources or experiential opportunities that would make socioecological violence intelligible for the students, and thus, could be ill-equipping students to understand and act in ways that lead to a socioecological violence-free world.

How to Cultivate Critical Awareness of Climate Change Using Socioscientific Perspectives
Eric Nolan*, California State University, East Bay, USA

ABSTRACT
The teaching and learning of climate science needs educational approaches that go beyond apolitical and amoral methods of curriculum delivery. Current climate education literature makes explicit the need for teachers to contextualize climate science in transdisciplinary ways to address social and environmental aspects of the issue lending credence that cultivating critical awareness is needed. To support learners in their understanding of the complexity involved with climate change, this empirical research conducted an exploratory case study that implemented a new curricular approach focused on the practice of perspective taking. Socioscientific perspective taking (SSPT) situates scientifically-based, open-ended, and oftentimes contentious issues with the centering of moral context, engagement, and etic/emic shifts in perspective. To achieve curriculum design capable of eliciting SSPT, the researcher used the Four Quadrants model from Integral Theory as a means of structuring perspective in ways that recognize experiential, behavioral, cultural, and social contexts of climate change. This study collected qualitative data from students who

took a 16-week college course and analyzed for SSPT features of their learning. Results show promise that teachers can use this curricular approach to cultivate critical awareness and shifts in perspective when students examine scientific information in their deliberation of climate change.

Strand 15: Policy, Reform, and Program Evaluation
SC-Organized Paper Set
Advancing Students' Scientific Literacy and Equitable and Socially Transformative Science Pedagogy
20-Mar-24, 9:15 AM-10:45 AM
Location: Directors Row I

"Post-truth" and Science Education: Towards an Updated Vision of Scientific Literacy
Katrin Vaino*, University of Tartu, Estonia
Anastasiya Astapova, University of Tartu, Estonia
Konstantinos Korfiatis, University of Cyprus, Cyprus
Oleg Popov, Umeå University, Sweden
Hans Orru, Umeå University, Sweden
Ana Valdmann, University of Tartu, Estonia

ABSTRACT
A powerful means against "post-truth," education could ideally create a scientifically literate public. However, the understanding of scientific literacy (SL) varies. The current study aims to review the existing literature on the challenges of "post-truth" to science education and how these challenges can be met through the focus on the three SL visions (I, II, and III).
Four groups of challenges to science education are identified: (1) lack of knowledge and skills to evaluate the reliability of information; (2) lack of understanding of the social construction of scientific knowledge; (3) lack of commitment to objective facts; and (4) lack of appreciation of the value and role of science in social decision-making. Several solutions are outlined to meet each challenge.
Conclusions: Without the proper scientific attitude, Vision I could help science denialists spread their message rather than help mitigate the situation. Vision II is more promising as it focuses on the nature of science and models the socio-scientific decision-making processes. The crucial aspect of challenges (3) and (4) is developing specific values and behavioral outcomes in students. Therefore, Vision III is the most viable definition of SL to fight post-truth. Still, it needs to be expanded to meet all four challenges.

Socially-Transformative Engineering Pedagogy
Senay Purzer*, Purdue University, USA

ABSTRACT
This evidence-based position paper challenges existing perspectives taken to integrate engineering into K-12 education and argues for the untapped potential of engineering education to promote justice, sustainability, and ultimately socially-transformative education.

The arguments are shaped by weaving together contemporary from the philosophers of engineering and technology, the justice-centered pedagogies developed for STEM education, and the lens of legitimation code theory explaining disciplinary knowledge. Throughout, I actively draw parallels between science and engineering education, revealing synergies and distinctions that enrich our understanding of engineering education. This position paper aims to propel discourse about the future of education and research with a perspective to reimagine the potential of engineering education in support of learners, the environment, and social justice.

"Filling the Gaps": Leaders Building Capacity for Equitable K-12 Computer Science Education in States

Stefanie Marshall*, Michigan State University, USA
Ain Grooms*, University of Wisconsin-Madison, USA
Joshua Childs*, University of Texis- Austin, USA
SJ Hemmerich*, University of Wisconsin-Madison, USA
Grace Tukurah*, Michigan State University, USA

ABSTRACT

The rapid growth of Computer Science Education (CSEd) in schools across the United States has led to new opportunities for educational leaders to implement equitable CSEd policies and practices strategically. CSEd must be addressed at the state level for substantive changes to support equitable CSEd adequately. However, the capacity for leading CSEd at the state level is often minimal. Therefore, CSEd leaders from various organizations are, as one participant in this study shared, "filling the gap" to build the necessary infrastructure for equitable CSEd in their state. Given the limited state allocations to CSEd, there are additional leaders who are filling the gaps, which this study explores. These CSEd leaders play a critical role in materializing equity in CSEd, as they guide state priorities and strategies, directly influencing state efforts. Two preliminary findings include: the capacity of CSEd state-level leaders suffers due to limited state allocation for human and fiscal resources specific to CSEd, and the equity agenda for CSEd in states is grounded in disorder and oppressive systems.

Roundtables Session 3

20-Mar-24, 11:00 AM-12:30 PM
Location: Plaza Ballroom ABC/DEF

Strand 11: Cultural, Social, and Gender Issues

Roundtable

The STEM Continuum: Understanding Female Perceptions

Carol Waters*, University of Houston-Clear Lake, USA
Mary Curtis, University of Houston-Clear Lake, USA

ABSTRACT

Today's world relies on science, technology, engineering, and mathematics (STEM) knowledge and innovations daily in personal and professional lives, which can improve lives

fundamentally, provide skills to solve problems analytically in fundamental ways, and help make sense of the world (Gulen, 2019; NRC, 2014). STEM permeates political, social, and economic realms while being a meaningful means to individuals through their environment and daily encounters with modern inventions. One issue facing STEM careers exists: finding a uniform definition of "STEM" (Bybee, 2013). The need for a "heterogenous understanding" could provide a broader view of STEM, thus advancing uniformity (NASEM, 2022, p. 23-24). Female perspectives enhance a comprehensive understanding while strengthening career equity and justice. Lessieg et al. (2019) call for case studies including female perceptions. This study sought to explore females' perceptions of STEM disciplines and employed the concept of intersectionality as the theoretical framework (Choo & Ferree, 2010). Researchers used inductive coding, and findings include one overarching theme: The STEM Array, with three subthemes. This study expands the limited research regarding females' perceptions of STEM and provides insight into provocative viewpoints on STEM disciplines and careers.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

Examining the Identity Transformation of African American Students in STEM Counterspaces

Lezly Taylor*, Virginia Tech, USA
Brenda Brand, Virginia Tech, USA

ABSTRACT

The global development of the STEM enterprise and workforce has bolstered national imperatives across the U.S. in support of the advancement of science, technology, engineering, and mathematics education (STEM) While these initiatives have contributed to modest increases in STEM participation, issues of underrepresentation persist as it relates to race, gender, and socioeconomic class due to the persistence of educational inequities which obfuscates goals to diversify STEM. As a result, some of the STEM initiatives aimed towards broadening the participation of historically underserved populations have been critiqued for its explicit focus on addressing the expanding workforce as opposed to a moral imperative to address and ameliorate educational inequities that socially construct underrepresentation for underserved populations. This case study focuses on the influence of a successful robotics program in a low socioeconomic community via examining factors that influenced the students' sense of belonging in STEM. It examined the learning environment as a counterspace for silencing stereotypical activating contexts that would cause them to disidentify with STEM. Vignettes of two students will be discussed in terms of their awareness of the stereotypical activating contexts and their experiences within the learning environment that supported them in developing a sense of belonging in STEM.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

The Impact of the NARST Sandra K. Abell Institute for Doctoral Students: A Counterstory

Seema Rivera*, Clarkson University, USA
Meredith Kier, William and Mary, USA
Julianne Wenner, Clemson, USA

Shelly Rodriguez, University of Texas at Austin, USA

ABSTRACT

In this roundtable, we discuss the outcomes of a supportive peer mentorship of four academic women who met through the Sandra K. Abell Institute (SKAI) and parallels with Yosso's (2005) Community Cultural Wealth Framework. This proposal is structured around a dominant story and a counter-story. One counter-story includes personal narratives, where we, as authors and women faculty, describe our experiences within academia. The 2011SKAI in Colorado Springs sets the context for the four women in this study. SKAI, sponsored by NARST, is held every other year for doctoral students selected to participate. A goal of this institute is to create an early mentorship model in which accomplished and tenured faculty mentors in the field of science education support doctoral students to develop their dissertations. Our data sources include emails, text chains, and journal reflections that focus on daily gratitude and personal journeys. We used reflexive methods to first individually document events as we recalled them and then checked with each other. We engaged in collective documentation of a timeline of our professional and personal travels together, personal and professional events in our lives where we have relied on each other, and salient stories that highlight friendship and career advancement.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

Science is For Us Too: Elevating Black and Latina Girls' Voices Through Community and Care

Laura Peña-Telfer*, Georgia State University, USA
Natalie King, Georgia State University, USA

ABSTRACT

Using community-based participatory action research (Holkup et al., 2004) situated within politicized and authentic care (Walker, 1983; Collins, 1991; Valenzuela, 1999) and community cultural wealth (Yosso, 2005) conceptual framework, Black and Latina girls and community co-researchers collaborated within the context of an informal STEM 4-week summer program to examine and reimagine STEM teaching and learning.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

Exploring STEM Teacher Educators' Perspectives on Culturally Responsive Practices

Uchenna Emenaha*, The University of Texas at San Antonio, USA
Jessica Gehrtz, The University of Texas at San Antonio, USA

ABSTRACT

Culturally responsive pedagogy (CRP) is a student-centered approach to teaching that utilizes students' cultural and individual identities to support academic development and critical thinking. Our work aims to understand what STEM teacher educators (STEs) think about as they work to become more culturally responsive themselves and as they support pre-service teachers' development. We interviewed ten STEs and analyzed transcripts using thematic analysis. Results highlighted that STEs' personal experiences, awareness of how

STEM content can address injustices, personal reflection, and belief that becoming culturally responsive is a continuous journey were central to STEs' thinking about the critical consciousness tenet of CRP.

Strand 10: Curriculum and Assessment
Work-in-progress Roundtable

A Design-Based Research Approach to Fostering Middle Schoolers' Socio-scientific Argumentation Skills

Samuel Bullard*, University of Minnesota, USA
Keisha Varma, University of Minnesota, USA

ABSTRACT

The Next Generation Science Standards require science learners to be able to engage in argumentation based on scientific evidence, yet challenges persist regarding the most effective methods to foster such skills among middle schoolers. In this paper, we describe the early stages of developing a Life Sciences curriculum unit designed for middle school students and teachers which is centered around NGSS-aligned science and engineering practices. This unit employs an online inquiry-based learning environment to engage students in scientific practices such as interpreting data, designing solutions, and engaging in argument from evidence regarding socio-scientific issues. In future iterations of this design-based research project, we plan to seek input from educational stakeholders to further refine the learning activities and materials to best scaffold middle school students' argumentation skills regarding socio-scientific issues.

Strand 10: Curriculum and Assessment
Work-in-progress Roundtable

Global and Local Dynamics Navigating Grand Challenges

Heewoo Lee*, University of North Carolina at Chapel Hill, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA
David Fortus, Weizmann Institute of Science, Israel
Rebecca Lesnefsky, University of North Carolina at Chapel Hill, USA
Keren Dalyot, Weizmann Institute of Science, Israel
Nannan Fan, University of North Carolina at Chapel Hill, USA
Zhen Xu, University of North Carolina at Chapel Hill, USA
Shira Passentin, Weizmann Institute of Science, Israel
Natasha Segal, Weizmann Institute of Science, Israel

ABSTRACT

The convergence of global and local dynamics in navigating significant challenges is a cornerstone of contemporary science education. As science standards evolve to encompass real-world complexities and socioscientific issues, students are encouraged to engage with multifaceted problems that exist across various scales. To address urgent global challenges, students must grasp the interconnectedness of issues, develop problem-solving skills, and understand the interplay between global phenomena and their local environments.

The Grand Challenges project pioneers an innovative approach to science education, merging global issues with local contexts. The pedagogical framework seamlessly transitions between global and local perspectives, allowing students to delve into complex problems while maintaining relevance to their lives. This approach empowers students to confront grand challenges by recognizing their roles as informed citizens who can enact change at both global and local levels.
Beyond students, this project empowers educators to adapt and collaborate, ensuring the sustained impact of the curriculum. Students develop essential problem-solving and critical thinking skills through interdisciplinary learning and engagement with real-world data. By fostering a sense of responsibility and action, the Grand Challenges project equips the next generation to confront the intricate challenges that define our world, ultimately reshaping science education for a globally interconnected future.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

Physics Research Experiences for Undergraduate Fellows: A Three-Year Study

Jennifer Wilhelm*, University of Kentucky, USA
Andrea Ratcliff, University of Kentucky, USA
Cameron Richards, University of Kentucky, USA
Heather McCall, University of Kentucky, USA

ABSTRACT
This convergent parallel mixed-methods study examined the effectiveness of a Physics/Astronomy Research Experiences for Undergraduates (REU) program. The perceptions of participating undergraduate students and their faculty mentors showed an overall positive experience where students gained research skills and physics content knowledge. Of the 23 NSF funded REU fellows, 12 were female. Gender differences were evaluated which revealed significantly higher female responses on their perceived confidence in conducting physics/astronomy research compared to male responses. Other findings showed how the REU program aided students in confirming their STEM career paths.

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

Centering Economic Equity in STEM: Challenges on the Road to Expanding Access to STEM Degrees

Leandra Cate, University of Washington, USA
Lia Wetzstein*, University of Washington, USA
Katie Kovacich, University of Washington, USA

ABSTRACT
Despite decades of focused effort to diversify STEM participation, there remains a gap in STEM participation and degree completion between students from low-income backgrounds and economically privileged students. One point of disjunction in the STEM pipeline for students from low-income families is the transfer pathway from two-year to four-

year colleges. This research describes the experiences of higher education STEM faculty and staff working in a consortium dedicated to improving STEM education and transfer processes in order to support low-income student success and degree completion. Drawing upon mixed methods data from the first two-years of a STEM equity initiative, this analysis outlines the conceptual and practical challenges that arose in the work to create student-centered pathways that increased engagement and degree completion for low-income students in STEM. We find that practitioners are working through a lack of clear data on low-income students as well as misinformation about STEM degree and career opportunities. Conceptually, they are dismantling the embedded assumptions about STEM students that shape organizational processes of learning and support. This work in progress offers STEM practitioners working toward economic equity an opportunity to examine the challenges that permeate all levels of STEM education and work together toward innovative solutions.

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

Formation of Disciplinary Science Identities in Upper Secondary School

Jonas Niemann*, University of Copenhagen, Denmark

ABSTRACT

The use of science identity has been applied to a variety of investigations studying the inequity of many aspects of STEM education. This paper explores the possible limits and possibilities of expansion of science identity when the investigated subjects have different STEM subjects to develop identity in. Discussion about how figured worlds, Biglan's dimensions, and the ideal student concept could enrich the theoretical backdrop when seeking to understand how such identities are developed. Preliminary results from a longitudinal study, encompassing focus group sessions and classroom observations across the upper secondary school subjects Mathematics, Chemistry, Physics, and Technology are given. Preliminary data reveals students' distinct rankings and perceptions of each subject, reflecting variations in subject characteristics and expectations. The paper underscores the importance of recognizing diverse disciplinary identities to inform equitable STEM education strategies and calls for continued discussions and advancements in this realm.

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

(re)Shaping Science Curricula: A Multicultural Approach

Sarah Ragoub*, University of Manitoba, Canada

ABSTRACT

Students who learn science do not necessarily want to become scientists, but it is critical that science education contributes to them becoming scientifically literate citizens. Furthermore, scientific literacy is a concept that cannot be alienated from the cultural diversity of students. The role of all science curricula as mandated governmental documents is pivotal in how and what science is taught in schools. This study examined the Discourse (Gee, 2001) used in the Manitoba Foundations for Scientific Literacy (Manitoba Education and Training, 2000) through a critical multicultural lens, drawing upon the concepts of affordances and

constraints (Gibson, 1979). The purpose of this critical Discourse analysis is to investigate the affordances and constraints of the curricular document for teaching multicultural science education, and how the mandated document supports, or hinders, students in developing science-literate identities that do not disregard their cultural backgrounds. To understand the role of governmental curricular documents more fully in teaching culturally responsive science, this study explored the meaning of multicultural science education and its presence, or lack thereof, in science curricula. Furthermore, this study aims to recommend language that could potentially (re)shape science curricula and give all students access to multicultural science education.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

A Longitudinal Study of Engineering Major Attrition: Gender Disparities

Niyazi Erdogan, Texas A&M University, USA
Olukayode Apata, Texas A&M University, USA
Karen Rambo-Hernandez, Texas A&M University, USA
Allison Esparza*, Texas A&M University, USA

ABSTRACT
Undergraduate student attrition in engineering majors remains a persistent challenge for academic institutions worldwide. This longitudinal study investigates the impact of the COVID-19 pandemic on the attrition rates of female engineering students. Drawing on the Social Capital Theory, we explore how economic, cultural, and social factors influence students' sense of belonging and integration within engineering programs during the pandemic. Leveraging institutional data from a Hispanic Serving Institution (HSI), we compare the persistence rates of sophomore students over four semesters before and during COVID-19 disruptions. The findings shed light on disparities in attrition rates and inform the development of targeted interventions to retain and empower female engineering students, contributing to a more inclusive and supportive engineering education environment.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

Using Active Learning Strategies to Close Equity Gaps for Biology Students of Historically Underrepresented Backgrounds

Stephanie Marin-Rothman*, Indiana University, USA

ABSTRACT
Equity, gaps are widely understood to be persistent disparities in achievement, or academic performance, between different groups of students, such as those grouped by race or ethnicity or gender (National Center for Education Statistics, 2022). Nevertheless, equity gaps continue to persist across campuses. A student-centered approach in which instructors use active learning techniques and peer support in their inclusive classes can help all students succeed, but particularly those who have been historically underrepresented in academia, closing equity gaps. By exploring the effects of active learning on the understanding of NOS as a measurement of achievement on my students, this research could illuminate ways to

close equity gaps and improve learning of NOS for a diversity of students both in my class and may be generalizable to other science classes as well. To improve student achievement, I will incorporate more active learning in my online classes. To assess if my students have achieved understanding of NOS, I will use the validated open-response Views of Nature of Science questionnaire (VNOS-B). Did active learning affect students understanding of NOS? Did the improvement differ between different groups of students, and did any equity gaps close? What active learning strategies facilitated understanding of NOS?

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

Navigating Emotions in Women Undergraduate Students' Developing Science Identities

Hillary Mason*, University of Nebraska-Lincoln, USA

ABSTRACT

Emotions can provide insight into the process of becoming a science person or developing a science identity. They are not only innate, but also felt, expressed, understood, and valued within societal norms and influenced by power relations. In other words, emotions are both personal and political. The myriad ways women in STEM experience emotions shed light on issues related to power, inequality, racism, and exclusion. While findings regarding science identity and women are burgeoning and encouraging, there are still several gaps in the literature, specifically concerning the role of emotions in the shaping of a science identity. This qualitative case study explores the emotions of women undergraduate STEM mentors as they participate in a year-long fellowship designing and facilitating STEM outreach with middle and high school students. A range of positive and negative emotions related to science identity aspects of performance, competence, and recognition are identified along with strategies for navigating the emotional challenges of developing science identities in STEM. Theoretical implications for further research in science identity are offered, as well as a discussion on the practical applications for supporting the emotion work of women's developing science identities.

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

Adapting the Family Resilience Framework to Understand Strengths of Latinx Families in Early STEM Learning

Smirla Ramos Montañez*, TERC, USA
Scott Pattison, TERC, USA
María Quijano, Metropolitan Family Service, USA
Shauna Tominey, Oregon State University, USA
Viviana López Burgos, TERC, USA

ABSTRACT

Deficit-based narratives have a profound impact, framing individuals, groups, and communities through perceived shortcomings, fueling stigmatization, discrimination, and stereotypes. Influential scholars like Ladson-Billings, Solózarno, and Yosso advocate shifting towards asset-based approaches. In STEM education, Funds of Knowledge and the

Community Cultural Wealth Framework emerge as transformative tools, yet gaps in their application persist. To foster equitable STEM education, concrete examples and outcome assessments of asset-based approaches are crucial. This work-in-progress follows a grounded theory approach to adapt Walsh's Family Resilience Framework, an asset-based framework from clinical practice to the context of informal STEM education. Its focus on family strengths, resilience, and communication makes it a promising tool to identify, describe and discern compelling connections between resilience, engineering, and executive function. The paper describes the process of adapting the framework, organizing the qualitative data collected across parent dialogue groups to identify different themes and relationships to resilience and share initial findings. This work would be of interest to researchers and practitioners dedicated to bridging the gap between research and practice and advancing the goal of fostering inclusive and transformative STEM education.

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

Mentors Matter: Queer Undergraduate Students' Perceptions of Research

Aramati Casper*, Colorado State University, USA
Kelly Lane, University of Minnesota - Twin Cities, USA
Sarah Eddy, University of Minnesota - Twin Cities, USA

ABSTRACT
Undergraduate research experiences are often considered to be a key to dismantling inequities in STEM. But, at the large-scale level, research experiences do not improve the retention of queer undergraduate students. In this U.S.-wide qualitative study on the experiences of undergraduate students with queer genders in biology-related majors we used master narrative theory to explore the research question: How do students' experiences with mentors and their research environment influence students' identity and sense of belonging as researchers? We recruited students from across the U.S.: 48 students completed at least one interview and 33 students completed all four interviews. We are using reflexive thematic analysis and are now developing protothemes. We developed two protothemes: 1) Spectrum of Welcoming Spaces with Mentors and 2) Seminar by Queer Biologist Increased Students' Connections to Research. One captures the range of students' mentorship climates. Two captures how an explicitly out queer speaker helped students feel more welcome. These findings demonstrate the importance of spaces that support students' identities and that providing access to a queer role model who discussed the salience of their queer identities in science can increase student belonging.

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

Boys Perceptions of Women Scientist: Shifting the Lens on Gender Disparity in STEM

Sara Sweetman*, University of Rhode Island, USA

ABSTRACT
To date we have little knowledge of how boys perceive women in STEM, but some indications suggest that boys have a negative association with girls in science from a young age.

Stereotyping can result in the perception that women's qualities do not match those needed to be successful scientists, and this lack of fit conceptual model contributes to discrimination and prejudices in the STEM fields. This disconnect leads to gender limiting behaviors for women and acts of gender discrimination for men. This research-in-progress aims to uncover at what age and to what degree boys and girls perceptions of women in STEM are disconnected from reality. Evidence from 500 children ages 3-8 drawings of women scientists will support a discussion about shifting foundational beliefs to acknowledge that gender-equity in STEM may not just be a problem to address with girls and women, but also with boys and men. The question becomes, how can what we know about boys and girls perceptions of women scientists help guide changes in policy and education to build a more collaborative and gender inclusive STEM workforce.

Strand 11: Cultural, Social, and Gender Issues
Work-in-progress Roundtable

Successful Scientists with (dis)Abilities: Identities and Views on the Nature of Science

Jonathan Hall*, California State University, San Bernardino, USA
Mila Rosa Carden*, University of North Texas, USA

ABSTRACT

Attempts to advance and facilitate science figured worlds that promote the identity development of students with (dis)abilities (StWDs) have been slow and limited. Disrupting perceptions and stereotypes about scientists to facilitate spaces that advance the science learning of StWDs necessitates examining the identity development of successful scientists with (dis)abilities (ScWDs). Also, there is potential that StWDs' science learning could be facilitated through lessons on the nature of science (NOS). A science identity formation and NOS conceptual framework frame the study. The following two research questions will guide this qualitative exploration: "What are the experiences of successful ScWDs?" and "What are successful ScWDs' NOS views?" Ten to 15 participants will be asked to interview for roughly one hour on three occasions. At the NARST 2024 conference, detailed descriptions of all participants' experiences will be discussed. To fit within the work-in-progress roundtable format, initial findings from interviewing two participants show that teachers recognized their science interests and provided personal support. The roundtable discussion will explore theoretical and practical implications based on the findings.

Strand 11: Cultural, Social, and Gender Issues
Roundtable

Science Teachers' Perspectives on Multicultural Dynamics in Science Classrooms

Selvet Ece Genek*, The Ohio State University, USA
Lin Ding, The Ohio State University, USA

ABSTRACT

In the rapidly evolving landscape of education, the significance of multicultural dynamics in science classrooms has come to the forefront, especially in diverse countries like Turkey. This study delves into the intercultural intricacies within Turkish science classrooms, aiming to acknowledge the challenges and opportunities arising from such dynamics. With a

theoretical foundation rooted in Culturally Responsive Science Teaching. Through a qualitative case study approach, data collected from two science teachers in different middle schools in Istanbul, a city marked by its cultural diversity. The questionnaire will delve into the dynamics, challenges, strategies, and outcomes observed within the multicultural science classroom context. The data analysis process involves systematic review and categorization of participants' responses to identify recurring themes, patterns, and codes addressing the research objectives. The study investigates teachers' experiences, strategies, and perceptions concerning culturally diverse students, revealing insights that contribute to effective pedagogical approaches and professional development. Additionally, the research aims to highlight the potential influence of its findings on educational policies, curriculum development, and the broader mission of promoting equitable education and societal inclusiveness.

Strand 12: Technology for Teaching, Learning, and Research
Roundtable

Virtual Learning Experiences: A Pilot Study of Technology Integration and Creative Production

Doris Chin*, Stanford Graduate School of Education, USA
Rachel Wolf*, Stanford Graduate School of Education, USA

ABSTRACT

This paper presents a pilot study of a project-based learning curriculum using innovative digital technology for creative production. The technology is a platform that allows users to both engage with and create their own interactive and immersive virtual learning experiences (VLEs). The study was implemented with two veteran teachers and their middle-school students during a two month-long climate science project. As a final project, students created VLEs summarizing their learning. Measures include student surveys and teacher interviews, both administered at the end of the study. Survey data indicate that the students enjoyed the technology and felt they learned both from creating their own VLEs, as well as exploring the VLEs of their peers. Interviews with the teachers revealed that they valued the technology for its ease of use and affordances for creativity and collaboration for their students. More importantly, their reflections illuminated how they adapted their pedagogical moves in response to student progress to scaffold the creative process. This included smaller, introductory projects, instructional framing, concrete examples, self-selected teams, and guiding rubrics.

Strand 12: Technology for Teaching, Learning, and Research
Roundtable

Investigating the Effectiveness of Using Technology for Remediation of High School Students' Misconceptions

Narendra Deshmukh*, Homi Bhabha Centre for Science Education, TIFR,, India

ABSTRACT

The purpose of this study is to investigate the effectiveness of integrating technology in the design and development of research-based remedial material. The researcher used the

ADDIE model for the development and implementation of remedial material. These remedial materials were developed using various multimedia technologies for certain topics in life processes in the subject Biology for high school students. Concept Based Objective Tests (CBOTs) were designed on the concepts taken from the high school level life processes topics in the study and data was collected and utilized to assess the effectiveness of the remedial programme. In the present study, a single group pre and post-test quasi-experimental study was conducted on 73 high school students of Class IX. t-test was used to analyze the data. The results of the study showed that integration of technology in design and implementation of research-based remedial material help teachers and students to overcome misconceptions and also provides hands-on experiences for students and allow them to interact with environments otherwise unavailable to them. The integration of technology in design and implementation of research-based remedial material plays a significant role to rectify students' misconceptions in biology.

Strand 12: Technology for Teaching, Learning, and Research
Roundtable

Harnessing Digital Curation for Personalized Science Learning in Science Secondary School

Gal Stern*, Technion, Israel Institute of Technology, Israel
Dina Tsybulsky, Technion, Israel Institute of Technology, Israel

ABSTRACT

This research study aimed to examine the contribution of digital curation on promoting personalized learning among secondary school science students. The participants were exposed to a science class that incorporated digital curation practices. Qualitative research was carried out to observe the students personalized learning, the data was collected at two crucial time points: pre-intervention and post-intervention. The findings indicated that digital curation not only facilitates personalized learning but also enhances student engagement and accountability in their learning process. This study contributes to the existing knowledge on personalized learning and provides practical insights for science educators, emphasizing the potential advantages of integrating digital curation into science instruction.

Strand 12: Technology for Teaching, Learning, and Research
Work-in-progress Roundtable

Investigating College Science Teachers' Digital Practices: A Global Study

Le Quan Ly*, University of Technology, Sydney, Australia
Tracey-Ann Palmer, University of Technology, Sydney, Australia
Kirsty Young, University of Technology, Sydney, Australia
Matthew Kearney, University of Technology, Sydney, Australia

ABSTRACT

The use of digital devices, such as laptops and mobile phones, to support teaching and learning has the potential to enhance science education. This global study investigates how college science teachers utilize portable digital devices to support undergraduate science education. A validated global survey was employed to examine these teaching practices through a digital pedagogical framework that highlights the distinctive constructs of

personalization (P), authenticity (A) and collaboration (C). At the time of this proposal submission, 130 teachers had fully completed this survey. The results highlight that teachers adopted practices featuring agency (P) and co-creation (C), followed by task authenticity (A) and online conversation (C). However, customisation (P) and context (A) subconstructs received relatively lower ratings. Most teachers implemented their digital learning activities for their first-year college students. The utilization of a variety of digital devices to support science learning activities was evident across multiple learning spaces. The findings suggest college science teachers may need to consider technology-mediated learning activities that further exploit contextualized and customized learning.

Strand 12: Technology for Teaching, Learning, and Research
Work-in-progress Roundtable

Connecting the Dots: How Students Communicate Through Virtual Field Trips

Aman Desai*, Stanford University, USA
Rachel Wolf, Stanford University, USA
Kristen Blair, Stanford University, USA
Doris Chin, Stanford University, USA

ABSTRACT

This work builds on and extends the growing body of research around technology for multimedia creative production in the classroom through a study using a virtual field trip platform, which offers the unique affordance of contextualizing student learning to place. The authors present ongoing work identifying and categorizing features of student digital products created as part of a middle-school life science project. The authors describe the technology and the context in which it was presented and used in the classroom. The authors detail the development of our coding scheme and suggest that creating connections between creators and the audience, amongst information included in the VFT, and between information and the space it is placed in underlie students' communication in this medium. The paper concludes by discussing directions for future work.

Strand 14: Environmental Education and Sustainability
Roundtable

A Scoping Review of the Intersection of Environmental and Science Identity

Roberta Hunter*, Michigan State University, USA
Susan Caplow, University of Montevallo, USA

ABSTRACT

The Anthropocene requires more scientists (doers of science) and citizens (users of science) who are capable of and interested in addressing emerging and complex environmental and scientific challenges (Clayton, 2003; Turgurian and Carrier, 2017). Science identity (SCID) and environmental identity (EID) have been shown to support goals that can help develop these citizens and scientists, but rarely has the intersection of the two been examined. To address this lack, we describe a scoping review of the literature that brings SCID and EID into conversation. Key findings of the review include that there is very little research on the two together, and much of that is in dissertations rather than peer-reviewed publications; that there was often conceptual overlap between the two; and there are significant diversity concerns - several studies did not address either the diversity of participants and others did not address how other identities could have influenced their research. We end with recommendations for the field, including a proposed instrument.

Strand 14: Environmental Education and Sustainability
Work-in-progress Roundtable

Developing a Background Survey to Measure Teachers' Knowledge and Practices Around Environmental Justice

Katy Nilsen*, WestEd, USA
Ashley Iveland, WestEd, USA
Melissa Rego, WestEd, USA

ABSTRACT

Historically underserved youth face challenges both at school and in their communities related to environmental education and sustainability. At school, youth lack access to high-quality science education due, in part, to the absence of resources and experiences that can impact the quality of teaching. In their communities, youth are impacted by pervasive environmental justice issues, including higher rates of disease, food insecurity, and rising temperatures. Connecting youth to these issues allows for learning to be framed on justice-centered phenomena, which has been shown to be a powerful and important way to support science and engineering learning; however, many teachers are ill-prepared to engage students in this way. We developed a teacher background survey to measure their science and environmental justice knowledge and practices. Survey development was informed by resources cited in a grant proposal, additional literature sources, and advisory board feedback. We piloted our survey, reviewed the results, and decided to make changes to it to clarify terminology, eliminate response choices with ambiguous results, focus on teachers' actual instruction, and delete items without meaningful results (e.g., with a perceived "right" answer). We intend to collect more data to further refine the survey so it can be widely used.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Work-in-progress Roundtable

Teachers' Attention to Student Interest in Selecting Anchoring Phenomena in an Environmental Justice Project

Susan Zwiep*, BSCS Science Learning, USA
Katherine Nilsen*, WestEd, USA
Jill Grace, WestEd, USA
Zoe Buck Bracey, BSCS Science Learning, USA
Ashley Ivelan, WestEd, USA

ABSTRACT

A Framework for K–12 Science Education outlines a vision for science learning anchored in understanding phenomena and solving problems. Through making sense of phenomena, students authentically engage in the real-world practices of science and develop disciplinary understanding. Having students provide input on phenomena to investigate can increase relevance and ultimately support their motivation to learn science over time. In this study, middle school co-development teachers, scientists, and expert science teachers developed grade-level phenomena surveys that pertained to their local, urban California context and aligned with the Next Generation Science Standards' performance expectations. The phenomena in the surveys focused on justice-centered issues around biodiversity. The process of brainstorming phenomena, selecting phenomena for inclusion in initial surveys, analyzing data collected from students, and modifying phenomena based on these results was documented through field notes and artifacts. Results showed that some grade-level surveys included phenomena that students found interesting that could be included in classroom learning sequences, whereas other surveys required further information in instances where prompts weren't interesting or students did not favor certain phenomena over others. This process of phenomena development and revision could help professional learning providers and researchers identify phenomena of interest to historically marginalized students.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
Roundtable

Student Expression of Transformative Learning Following Science Instruction Using a Current Case of Environmental Injustice

Shondricka Burrell*, Morgan State University, USA

ABSTRACT

Students in minoritized communities are more likely to lack access to quality science curricula in alignment National Research Council (2012) recommendations for effective learning. To address this opportunity gap, I developed a pedagogical model informed by the socio-cognitive constructs of transformative learning (perceived value, relevance, and application of science) and place-based inquiry. The water-quality themed curriculum used the water quality crises of Flint, Michigan as a case study to teach both Earth science content and practice. Preliminary iterative content analysis of student reflections revealed evidence of transformative learning confirming the efficacy of the approach in supporting student learning and science perception.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Roundtable

Conceptions of Uncertainty: A Delphi Study With Science Education Researchers and Scientists.

Simon Blauza*, University of Münster, Germany
Kerstin Kremer, Justus Liebig University, Germany
Benedikt Heuckmann, University of Münster, Germany

ABSTRACT

The ability to understand and manage the uncertainty inherent to science becomes fundamental given the mounting complexities of our world. Previous research emphasized the importance of addressing uncertainty in science education, yet the types of uncertainty discussed varies between subjects: epistemic, aleatoric, measurement, structural, and consensus uncertainty. To broaden an explicit interdisciplinary perspective towards uncertainty, we conducted an online-based Delphi study with 33 experts from STEM education and scientific research in German-speaking countries. The experts provided their conceptions as written statements in response to definitions of uncertainty and rated their agreement, added missing aspects, and reported important types of uncertainty for science education. The findings revealed that while the experts largely agreed on the relevance of uncertainty in STEM education, they offered nuanced critiques and new insights e.g., into the nature and sources of uncertainty. Expert conceptions and varying hierarchies were strongly influenced by subject-specific traditions and paradigm. We discuss the findings with respect to the idea of an integrated framework of uncertainty. This research holds significance for science educators and STEM instructors interested in nature of science, philosophy of science as well as interdisciplinary science education.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Roundtable

The Integration of the Nature, Philosophy, and History of Science in Canadian Science Education Degrees

Ellen Watson*, Brandon University, Canada
Sarah Ragoub*, University of Manitoba, Canada

ABSTRACT

Studies have shown that students' beliefs about science are directly influenced by those beliefs espoused by their teachers. As a result, preparing future science teachers to teach science for the rest of us requires teachers to gain a deep knowledge of the epistemic underpinnings of science. To acquire this deep knowledge, future science teachers need to engage with the nature (NoS), history (HoS), and philosophy (PhoS) of science in a meaningful way throughout their teacher education. To gauge future science teacher engagement with the NoS, HoS, and PhoS across Canada, this study asks, (1) do Canadian science education pre-service teacher programs engage students with the HoS, NoS, and PhoS? and (2) if these programs do engage students with the HoS, NoS, and PhoS, at what point in their education do pre-service teachers formally engage with these ideas? Results of an environmental scan of program websites and university course calendars of 53 universities offering 63 secondary science education programs will be presented. The inclusion of NoS, HoS, and PhoS concepts in science content courses and science methods courses in these programs and considerations for preparing future science teachers to engage with the NoS, HoS, and PhoS ideas are discussed.

APISER RIG
Sponsored Session
Asian and Pacific Islanders in Science Education Research Poster Session
20-Mar-24, 11:00 AM-12:30 PM
Location: Governor's Square 10

Asian and Pacific Islanders in Science Education Poster Session

ORGANIZERS
Xinying Yin, California State University-San Bernardino, USA
Jennifer Tripp, University at Buffalo, USA.
Hosun Kang, University of California-Irvine, USA

PANELISTS
Pauline Chinn, University of Hawaiʻi at Mānoa
Andy Trinh, University of California, San Diego, USA
Meena Balgopal, Colorado State University, USA
Emily Slater, Utah State University, USA
Joe Deluca, University of Georgia
Jaesung Park, University at Albany-SUNY, USA
Tony Chontong, California State University, Fresno, USA

ABSTRACT
This Asian and Pacific Islander -Research Interest Group sponsored poster session is to provide a platform for NARST members to share their perspectives and experiences in science education research involving learners and/or educators of Asian and Pacific Islander (API) heritage. This session will feature seven poster presentations, including empirical studies and theoretical/position papers, that promote diversity, equity, justice, and inclusion in science education research involving learners and educators of Asian and Pacific Islander heritage. The seven studies will discuss culturally relevant issues in science curriculum, learning, teaching, and teacher professional development in both K-16 formal and informal educational contexts.

Posters:
Emily Slater, Tyler Hansen, Utah State University
Pacific Island teachers' experiences of culturally-responsive professional development in community-centered science

Andy Trinh, University of California, San Diego; Desiree Forsythe, Chapman University; Jessie Tsai, Chapman University; Lillian Lee, Carleton College; Jeremy Hsu, Chapman University; Rou-Jia Sung, Carleton College; Stanley Lo, University of California, San Diego
Asian American Student Experiences in STEM

Joe DeLuca, Emily Adah Miller, Hong Tran, University of Georgia
Promoting Vietnamese American elementary students' localized science knowledge and empowering them to create a more sustainable world

Tony Chontong, Emily M. Walter, Hannah Gill, California State University, Fresno
Secret Sauce: Southeastern Asian Culture as a lens for Culturally Sustaining Pedagogies in Majors' Biology

Jaesung Park, Alandeom W. Oliveira, University at Albany-SUNY
Responding to Culture: A Theoretical Position on Culturally Responsive Science Teaching in South Korea

Meena Balgopal, Tenzin Sonam, Colorado State University
Perspectives of Tibetan Buddhist monastics on how to teach academic science in culturally relevant ways

Pauline W. U. Chinn, Kaleolani A. Hanohano, Binh Le, Alika Maunakea, Alison Yasuoka, Stefan Moisyadi, Ruben Juarez, University of Hawai`i at Manoa
COVID-19 Professional Development in Hawai`i: Teachers as Public Health Educators

---

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set
Unraveling Students' Scientific Understanding Across Disciplines
20-Mar-24, 11:00 AM-12:30 PM
Location: Plaza Court 2

Exploring Relationships between Elementary Students' Mechanistic Reasoning and Argumentation about their Engineering Design Solutions
Mustafa Topcu*, Yildiz Technical University, Turkey
Kristen Wendell, Tufts University, USA

ABSTRACT
Mechanistic reasoning – an approach to sensemaking – and argumentation – a form of discourse – are important parts of scientific and engineering thinking. Thinking like a scientist or engineer involves both individual acts of sensemaking and social acts of discourse to share the products of that sensemaking with others. In this study, we explored relationships between elementary students' mechanistic reasoning and argumentation about their engineering design solutions. We analyzed examples of mechanistic reasoning and argumentation elements from three curriculum units in third- through fifth-grade classrooms. Students' mechanistic reasoning and argumentation elements showed similar patterns across engineering units. At least one time all students showed all mechanistic reasoning and argumentation elements across units on water filter and retaining wall design. In a unit on playground design, only one student did not reveal one element of mechanistic reasoning (connecting entity factor) and one element of argumentation (reasoning). Because

of the complementary nature of these reasoning types, combining or giving attention to both types in classrooms can generate rich engineering learning opportunities for elementary students. Teachers and researchers can use the frameworks presented in this work to include mechanistic reasoning and argumentation elements as a part of engineering practices in their classrooms or research.

Students' Ideas About Heat Transfer Tell Us a Lot: Are We Heeding?

Rajashri Priyadarshini*, Indian Institute of Technology Bombay, India
Chandan Dasgupta, Indian Institute of Technology Bombay, India
Sahana Murthy, Indian Institute of Technology Bombay, India

ABSTRACT

Students begin learning science before they are formally taught about them. It is pertinent for educators to understand what ideas students bring with them while teaching them about scientific concepts. Intuitive notions significantly impact students' scientific comprehension, often working unconsciously. While explicit aspects of student knowledge are extensively explored, the role of implicit ideas, especially in shaping students' ideas about everyday phenomena like heat, remains underexplored. This study addresses this gap by analyzing an eleventh-grade group's implicit knowledge and its role in students' explanation of heat transfer. It examines how implicit and explicit knowledge interacts in their understanding of the phenomenon. Findings reveal material experiences shaping heat transfer reasoning, driven by sensory cues and implicit attributions of agency. Integration of implicit 'balancing' notions with formal concepts occurred during macroscopic representation, guided by analogies. Aligning implicit and formal knowledge at the microscopic level poses challenges. Our study supports previous findings on students' heat-related ideas, highlighting the prominence of intuitive elements over formal concepts during tangible experiences, while also emphasizing the need for careful use of analogies, consideration of culturally relevant language, and the integration of implicit knowledge in teaching various scientific phenomena.

Greek Secondary School Students' Teleology and Essentialism Conceptions About Genes

Florian Stern*, University of Geneva, Switzerland
Panagiotis Stasinakis, Ministry of Education Greece, Greece
Antonios Krimitzas, Ministry of Education, Greece
George Verroios, Ministry of Education, Greece
Katerina Gioti, Ministry of Education, Greece
Andreas Mueller, University of Geneva, Switzerland
Kostas Kampourakis, University of Geneva, Switzerland

ABSTRACT

Biology education research provided evidence that human intuitions can influence students' understanding of biological phenomena. One example is design teleology, the intuition that organisms' characteristics were designed for a goal. Another example is psychological essentialism, the intuition that organisms' essences are fixed. Previous research has found that both these intuitions are conceptual obstacles for learning evolution. In the current study, we investigated whether such intuitions can also hinder the learning of genetics. To do this, we used a validated test about human intuitions and genetics, that consists of 20 items and 3 subdimensions (1/ teleology, 2/ essentialism about fixity, 3/ essentialism about homogeneity). The test was translated and back-translated from English to Greek, and was administered in a pilot study. Then, a sample of n=1403 Greek students aged 12 to 17 years completed the test. Our findings indicated the strong presence of teleology misconceptions about genes (>60% of students' answers), and the presence of essentialist misconceptions about the homogeneity and fixity of genes (>45% and >30% of students' answers, respectively). Such misconceptions significantly change with age, which may come from schooling effect. These results reflect a tendency of Greek students to think about genes in a scientifically inaccurate intuitive way.

Exploring Epistemic Heterogeneity in a Critical Place-based Science Curriculum
Hannah Ziegler*, Vanderbilt University, USA
Heidi Carlone*, Vanderbilt University, USA
Zachary Conley, Vanderbilt University, USA
Yelena Janumyan Doe, Vanderbilt University, USA

ABSTRACT
Our study explores middle school students' epistemic heterogeneity and diverse sensemaking within a critical, place-based Urban Heat Islands and Tree Equity (UHITE) unit. Students developed an understanding of climate issues in local spaces, applied field science practices, critically examined notions of social justice, and summarized their learning through multimodal storytelling. The findings highlight the significance of criticality and local contexts as students creatively synthesized their everyday lives with scientific domain knowledge. The UHITE curriculum yielded diverse and imaginative representations of scientific issues that reflected students' epistemological resources grounded in social, political, and cultural contexts. Hence, this work supports students moving in, between, and through multiple ways of knowing in science education.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set
STEM Expectations, Opportunities, Skills
20-Mar-24, 11:00 AM-12:30 PM
Location: Plaza Court 5

Science Career Expectations and Science-Related Motivation: A Latent Profile Analysis Using PISA 2015 Data
Yanfang zhai*, Capital Normal University, China
Xiufeng Liu, University at Buffalo, State University of New York, USA

ABSTRACT
In response to growing concerns about students' low expectations for science-related careers, this study utilised a person-centered approach to investigate the association

between students' motivation profiles and their science career expectations using the 2015 Programme for International Student Assessment (PISA) data set. Analysing responses from 9841 15-year-old students in China through latent profile analysis, the study revealed: (i) Six distinct student profiles were identified; (ii) Significant variations were observed in perceived instructional practices and science learning engagement across student profiles; (iii) The index of economic, social, and cultural status (ESCS), school location, and gender served as predictors for students' profiles; and (iv) Students' profiles significantly differed in science career expectations. The research makes three significant contributions: (i) Identification of non-linear relationships between science-related motivation and science career expectations, challenging conventional linear viewpoints; (ii) Significant disparities in science-related motivation profiles among students based on their socioeconomic backgrounds, school locations, and gender; and (iii) Utilization of person-centered methodology for subgroup identification, enabling insights into diverse science learning characteristics, further enriches the understanding of science career expectations within heterogeneous student groups.

Nice to Run into 'Roo: Examining Middle School Students' Conceptual Understanding of Change over Time

Rochelle Cassells*, University of Utah, USA
Harini Krishnan*, University of Utah, USA
Louisa Stark, University of Utah, USA

ABSTRACT

This study examines the conceptual understanding of evolution and change over timein a sample of middle school students following engagement in a Next Generation Science Standards-friendly curriculum that integrates heredity and evolution concepts. This novel curriculum was designed to target prevalent student misconceptions about change over time. We examined students' conceptual understanding using stimulated recall interviews where they were asked to identify problems and inconsistencies with evolution-related science ideas in an illustrated tall tale. Our findings demonstrate that while all students could recognize at least one problem and inconsistency in the ideas presented in the story, they struggled to generate sound scientific explanations for those problems. Significant gaps remained in students' ability to integrate concepts of heredity and natural selection to explain change over time. Our work is of interest to curriculum developers and teachers, particularly those interested in developing activities that best support students' abilities to sensemake and articulate complex scientific concepts.

Identifying STEM Opportunities for K-12 Students within a District

Elizabeth Crotty*, University of Wisconsin - Eau Claire, USA
Emily Landwehre, University of Wisconsin - Eau Claire, USA
Whitney Onyancha, University of Wisconsin - Eau Claire, USA
Elizabeth Stretch, University of Minnesota, USA

ABSTRACT
STEM education remains a point of emphasis in the United States with the inclusion of engineering in the Next Generation Science Standards (NGSS Lead States, 2011). Yet, Identifying and describing the STEM landscape within a public school district can be difficult. This work provides a process for examining the STEM opportunities that students experience within a large public midwestern district and outlines the resulting categories of STEM experiences that are offered. This work provides a process for understanding the STEM landscape within a district in relation to core tenets of STEM that are emphasized in the research literature. This process of mapping the STEM experiences that are offered within a district allows for intentional planning for future programming efforts for summer engagement in STEM that is meaningful and tailored to the needs within the district.

Non-Science Performances in Small Group Positioning
Marta Stoeckel*, University of Minnesota, USA
Anjar Putro Utomo*, University of Minnesota, USA

ABSTRACT
When working in small groups, students are constantly using positioning to send each other messages about who is good at science and who is a valuable member of the group. Many of these messages, however, focus on performances and competencies that are not directly related to science. In this study, we analyzed video of students working in small groups in a high school physics classroom to identify exchanges where students used skills and actions not directly related to physics, such as grammar or reading analog clocks, in order to position a peer within the group. These exchanges were typically used to position someone as less valuable to the group based on the other skills under discussion. We examined both a mixed gender group and a group of all boys, and found only one of these exchanges from the all boy group and several from the mixed gender group. In the mixed gender group, these exchanges were typically used to devalue a contribution made by the lone girl in the group when her physics was otherwise correct, suggesting that gendered storylines were at play. These results have implications for why girls often feel they receive less peer recognition than boys.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies

SC-Organized Paper Set

Socioscientific Foci for Scientific Literacy

20-Mar-24, 11:00 AM-12:30 PM

Location: Directors Row I

Towards Transformative Science Education for Responsible Citizenship: Investigating Science Teachers' Integration of Informed Decision Making
Erik Barendsen*, Radboud University, Netherlands
Ineke Henze, Radboud University, Netherlands
Dury Bayram, Eindhoven University of Technology, Netherlands

ABSTRACT
Learning to make informed decisions on socio-scientific issues (SSI) is considered a crucial step towards taking action in complex real life situations, and is therefore pivotal in modern transformative science education.
This paper explores teachers' integration of informed decision making in science subjects while designing subject-specific citizenship lessons on current SSI. Understanding teachers' capacities with respect to this integration is important to establish effective teacher education and continuing professional development.
The study took place in the context of a series of workshops on the goals and instructional approaches for informed decision making in science-specific citizenship education. Our in-depth multiple-case study involves three teachers in different science subjects. The data was collected through four teacher interviews. A qualitative content analysis was performed in two coding cycles using the framework of pedagogical design capacity.
We found distinguishing features and common patterns in the the teachers' use of personal and external resources for the design of up-to-date integrated citizenship lessons on informed decision making.
Our study concludes that science teachers are able to design citizenship lessons when providing them with relevant instructional resources. These include professional development workshops with instructional approaches, example curriculum materials, and other tools.

Collective Pedagogical Content Knowledge to Develop Teaching About Sustainability Issues
Annika Forsler*, Halmstad University, Sweden
Pernilla Nilsson, Halmstad University, Sweden
Susanne Walan, Karlstad University, Sweden

ABSTRACT
Learning about sustainability issues is crucial for upper secondary students as they will enter adulthood within a short time. This study aimed to explore how science teacher teams in Swedish upper secondary schools can develop their knowledge and expertise for teaching about sustainable development (SD) through collective reflections with the support of the reflective tool Content Representation (CoRe). Twelve in-service science teachers participated in a study to investigate their development of Pedagogical Content Knowledge (PCK) for teaching SD. The qualitative research design included semi-structured interviews and audio-recordings from collective meetings with science teacher teams. The findings covered four themes about how the collective reflections with support of the CoRe tool stimulated teachers' collective PCK development for teaching SD: (1) Creating structure and a focus for learning conversations, (2) Modification of the teaching approach, (3) Development of new content knowledge and pedagogical knowledge in SD, and (4) Shared language to stimulate equal opportunities for students to learn SD. As such, the results from the study provides important implications for how reflection among science teacher teams can be stimulated to promote teachers' knowledge development for teaching about SD.

Cultivating Informed Citizens Through Socioscientific Issues: A Systematic Review
Jing Lin*, Beijing Normal University, China

ABSTRACT

As the theme of 2024 NARST conference calls for, school science, aimed at promoting scientific literacy for all, should benefit students from SSI-based teaching to be competent in their future. However, due to the nature in the comprehensiveness and complexity of SSI, how to select proper SSI and conduct effective teaching is big challenge for everyone. To make an effort in this regard, this study conducted a systematic review on 83 empirical studies from 2000 to 2022 and sorted out efficient measures in terms of the issue selection, teaching objectives and teaching strategies. The results showed there were some remarkable innovations in these included studies. For example, many vital issues were explored in science classrooms such as genetic engineering, sustainability, climate change and conservation of biodiversity. Their teaching objectives extended beyond cognitive gains and advanced students' interdisciplinary knowledge, higher-ordered thinking and big ideas. Additionally, these teachings were student inquiry centered and took full advantage of the controversial nature of SSI and placed great emphasis on the students' embodied feelings and showed the role of technology empowerment. Findings of the study may add evidence for improving SSI-based teaching and facilitate deepening reform of science education to cultivate high-quality citizens.

Colorado Science Education Research

Scoping Review of Articles Measuring Climate Change Acceptance
Jessica Duke*, University of Northern Colorado, USA
Emily Holt, University of Northern Colorado, USA
Karliegh Wattier, University of Northern Colorado, USA

ABSTRACT

While many Americans accept that climate change is occurring, little is known about the specific facets of climate change acceptance or denial (e.g., severity, cause). Several instruments exist to measure climate change acceptance; however, it is unclear who is using these instruments, what populations they are targeting, and whether studies measuring climate change acceptance are increasing over time. Currently, no unified synthesis exists to document the types of studies that have been conducted investigating climate change acceptance in the past several decades. The goal of our study is to identify and summarize published studies measuring climate change acceptance in the US by investigating the (1) populations targeted, (2) chronology of publications, (3) journals where these studies are published, and (4) author(s) of acceptance metrics used. We found most studies measuring climate change acceptance have been published since 2012 in a variety of unique journals spanning multiple disciplines and mainly target the general public. Additionally, most studies report using self-created climate change acceptance instruments. Our results highlight the need for a climate change acceptance instrument that is both validated and interdisciplinary in nature.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Examining Approaches for Supporting Student Performance
20-Mar-24, 11:00 AM-12:30 PM
Location: Governor's Square 12

Implementing Brokering and Multi-mentor Approaches to Support Retention of Undergraduate STEM Majors from Minoritized Groups
Stacy Olitsky*, Saint Joseph's University, USA

ABSTRACT
Diversifying STEM fields is vital for many reasons, including benefits of expanded talent, varied perspectives, and equitable opportunities. However, studies have shown obstacles to retention in STEM majors for students from minoritized groups. While mentoring and research opportunities can support identity and retention, effectiveness of mentor/student relationships may be impacted by biases, stereotype threat, and/or cultural anxiety, particularly when the mentor's and mentee's identities do not match. Yet matching students with faculty mentors who have similar race, ethnicity and gender identities is not always feasible. This three-year study focuses on the experiences of seven students from minoritized groups working towards bachelor's degrees in STEM fields in a program that provides scholarships and mentoring. Only some of the students had similarities in identities with their assigned mentors. Results suggest that retention can be supported by encouraging brokering and multi-mentor approaches, as these enable students to seek advice from varied faculty members for different purposes, provide multiple opportunities for identity development, and mitigate challenges such as negative stereotype threat. This study explores supporting approaches to mentoring that extend beyond dyads, to a networked community of faculty members intent on supporting students from minoritized groups in STEM fields.

Examining Students' General Chemistry Performance Following a Voluntary Supplemental Course
Brayan Diaz*, North Carolina State University, USA
Tyler Harper-Gampp, North Carolina State University, USA

ABSTRACT
Despite the importance of STEM careers, there is a global concern over the shortage of STEM graduates with low graduation rates and retention presenting a significant challenge for higher education institutions. This is further amplified by diverse first-year student populations with varying needs, preparations, and backgrounds. Therefore, this study assesses the advancement of students' self-efficacy and knowledge within a self-directed online supplementary chemistry course and its impact on their subsequent performance in first-year general chemistry. The online course was strategically designed to support students' transition from high school to college. To gauge the course's influence, pre- and post-chemistry knowledge tests, alongside pre- and post-self-efficacy assessments, were

administered. Students who completed the entire online course exhibited a 14% increase in self-efficacy (increasing from 3.00 to 3.46 on a 1-5 scale) and a 36% increase in knowledge (advancing from 4.15 to 5.63 on a 0-10 scale). Remarkably, their heightened self-efficacy levels and performance in the post-knowledge test displayed a direct correlation with their achievements in their general chemistry course during their inaugural semester at college.

Undergraduate STEM Students' Expectations and Value Perceptions from a Longitudinal STEM-focused Support Program Experience

John Tillotson*, Syracuse University, USA
Gaye Ceyhan, Bogazici University, Turkey
Gizem Ozyazici, Syracuse University, USA
Amanda Surman, Syracuse University, USA

ABSTRACT
This qualitative study examines a longitudinal STEM-focused support intervention program designed to provide social, academic, professional, and financial support to cohorts of ethnically diverse, academically talented, low-income STEM students during their first two years of college. This investigation utilizes the expectancy-value theory to examine undergraduate students' expectations and value perceptions of their learning experiences throughout the STEM intervention program. This study asks the following questions: (1) What are the expectancies of STEM undergraduates participating in the support program? (2) How valuable do the STEM undergraduates find these support program interventions? The results demonstrate that participants entered the support program holding expectations largely focused on their research and skill development, academic success in STEM courses, and achieving a STEM degree. Fewer participants identified expectations regarding the social and community building aspects of the program initially, yet these facets were among the most highly valued by undergraduates at the conclusion of their first and second years in the program. The study sheds important light on where perceptions align, and where they diverge, and the implications for STEM educators and policymakers who seek to design more robust professional development programs to broaden participation in STEM for students who have historically been marginalized.

Investigating Responsive Pedagogical Approaches to Promote University Students' Trust in Well-Established Science

Benjamin Janney*, Texas A&M University, USA
Benjamin Herman, Texas A&M University, USA
Tamara Powers, Texas A&M University, USA

ABSTRACT
This presentation reports the findings of an exploratory investigation that delves into the perspectives of non-science major students concerning the credibility of five well-established scientific concepts (e.g., climate change, the Big Bang theory, the age of the Earth, evolution, and vaccines). The factors associated with these credibility perceptions guided the integration of a comprehensive pedagogical approach known as responsive and reconciliatory pedagogy (R&R) into a general university science course for non-science major

students. These instructional strategies tailor learning experiences to address cognitive deficits and motivated reasoning that may lead to perceiving scientific concepts as less than credible.
The results underscore that students harbored significant misconceptions regarding the nature of science and held religious beliefs that hindered their acceptance of scientific ideas prior to the course. Following the intervention course, significant shifts in credibility perceptions occurred, particularly evident in evolution, the Big Bang theory, and the age of the Earth. This presentation will present findings concerning (1) the factors linked to credibility perceptions for well-established scientific concepts and (2) the influence of R&R practices on shaping these credibility perceptions. Finally, recommendations for implementing such strategies within university science courses will be presented.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set
Meaningful Science Learning Experiences for High Schoolers and Undergraduates in Informal Contexts
20-Mar-24, 11:00 AM-12:30 PM
Location: Governor's Square 11

Contributing and Belonging: Mentorship and Participation in a Research Experience for Undergraduates
Stephen Burgin*, The University of Arkansas, USA
Zephaniah Greenwell, The University of Arkansas, USA

ABSTRACT
In this presentation, we share the results of an ethnographic study of an NSF funded Research Experience for Undergraduate students that took place over 10 weeks during the summer within two different biological sciences laboratory groups. Three undergraduate students from an underserved population worked with one faculty member and three graduate students both in the laboratory and out in the field. Two undergraduate students researched the transmission of conjunctivitis in populations of captive finches and in wild mountain bluebirds, and one undergraduate student worked in a lab studying protein structures through gel electrophoresis and western blotting. Through observations and focus group interviews we were able to gain a deep understanding of the characteristics of mentorship that took place and the impact that the experience had on the undergraduate students. Specifically, mentors made very intentional decisions regarding their facilitation of undergraduate involvement that resulted in students and mentors expressing that valuable contributions were made to authentic scientific research. Undergraduate students also shared that they felt like they genuinely belonged to the lab groups where they were placed.

Environmental Education Internships Over Time: How Current and Former Interns Describe Their Experiences
Rachel Stronach*, University of Massachusetts Dartmouth, USA
Hamza Malik, University of Massachusetts Dartmouth, USA

Stephen Witzig, University of Massachusetts Dartmouth, USA

ABSTRACT
Undergraduate STEM internships have many benefits such as helping participants envision their career path, acquire skills relevant to future careers, improve their academic performance, and participate in authentic experiences that can broaden participation in science (Binder et al., 2015; Borgerding, 2015; Rivera et al., 2022; Scholz et al., 2004). This qualitative case study utilizes Lave & Wenger's (1991) Community of Practice (CoP) approach to explore the experiences of undergraduate environmental education interns in a long-standing (over 30 years) program situated at a non-profit environmental organization. Participants' collective internship experiences in this study spanned the course of 25 years. What we uncovered is the long-term benefit of these internships to the individual participants and the host organization itself, which aligns with general findings in the internship literature (Binder et al., 2015; Borgerding, 2015; Hutchison et al., 2016; Rivera et al., 2022; Scholz et al., 2004). Key findings revolved around the importance of representation in science education spaces (Rivera et al., 2022), family influence in both career and educational choices (Humayon et al., 2018; Vautero et al., 2021; Whiston & Keller, 2004), and the benefits of science experiences in an informal context (NRC, 2009; 2015).

Urban Farming within a Transdisciplinary Research Practice Partnership
Marc Sager*, Southern Methodist University, USA
Anthony Petrosino*, Southern Methodist University, USA

ABSTRACT
One way to create more sustainable transdisciplinary research networks is through establishing research practice partnerships (RPPs) between an urban farm, a faculty and staff from a Historically Black College, and researchers at a medium-sized private university. We investigate student-workers' resiliency at an urban farm situated on the campus of a Historically Black College. This study draws from literature that explores tensions between informal learning environments and formal spaces, equitable food and farming systems, and the resiliency of farm works, and is grounded in the theory of situated cognition. Utilizing a participatory design research approach, we conducted semi-structured interviews and deductively analyzed the data using critical food systems education. Our findings revealed what socio-scientific topics are discussed on an urban farm: 1) how participants were eager to engage with the local community; 2) how the participants demonstrated resiliency while working on the urban farm; 3) how power dynamics played a pivotal role to inform the direction of the urban farm; 3) how participants consider the community's access to healthy foods an important mission for the farm. Our findings help deepen our understanding of the socio-scientific issues within an informal science education space.

Perceived Authenticity of Out-of-school Chemistry Learning Environments
Christian Strippel*, Ruhr-University Bochum, Germany
Lena Finger, Ruhr-University Bochum, Germany
Joachim Wirth, Ruhr-University Bochum, Germany
Katrin Sommer, Ruhr-University Bochum, Germany

ABSTRACT
Non-formal settings, such as university outreach laboratories, provide opportunities to engage students in authentic learning. Authenticity is supposed to affect learners' motivation and interest, and, consequently, conceptual learning. However, it is often unclear how authentic non-formal settings really are, and which of the characteristics of the specific learning environments in these settings contribute to their level of authenticity. To examine this issue, this study investigates the perceived authenticity of two one-day chemistry learning environments at a university outreach laboratory for high school students. The learning environments were nearly identical but differed concerning the role of the research question and the experimental design. The sample comprises N = 263 students (age M = 16.48 years). Data were collected administering a multi-dimensional authenticity questionnaire directly after participation in the learning environments. It turned out that both learning environments are perceived as highly authentic regarding place and methods, less authentic regarding the instructor and only moderately authentic regarding innovation. Additionally, a significant difference between the two learning environments was identified in the dimension innovation. This indicates that the specific content of the learning environment influences the perceived authenticity. This should be considered when designing non-formal as well as formal authentic learning environments.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set
Exploring How Preservice Teachers Engage with Engineering Practices Across Different Contexts
20-Mar-24, 11:00 AM-12:30 PM
Location: Plaza Court 4

Pre-service Teachers Depiction of the Nature of Engineering via the Family Resemblance Approach
Tamar Ginzburg*, Technion - Israel Institute of Technology, Israel
Miri Barak, Technion - Israel Institute of Technology, Israel
Sibel Erduran, The University of Oxford, United Kingdom

ABSTRACT
Pre-college engineering education has been a recent goal of educational systems, aiming to promote the skills and knowledge for thriving in a technology-driven world. A rapidly changing world brings complex challenges; therefore, pre-service teachers are the future change agents, who will shape the next generation's understanding of it. The goal of this study was to examine how pre-service science teachers depict and develop their awareness of the 'nature of engineering' (NOE). The study utilized the Family Resemblance Approach (FRA) as a theoretical and pedagogical framework, focusing on pre-service teachers from science and engineering backgrounds. Drawings and written explanations were analyzed to examine the development of NOE understanding before and after professional development.

Findings show that the cognitive-epistemic domain of FRA is significantly more evident in pre-service teacher understanding than the social-institutional domain. Overall, those with an engineering background hold a more holistic view of NOE. However, after exposing teachers to FRA-related activities, there was a significant increase in the reference of participants from both backgrounds to social-institutional aspects of NOE, mainly to social values. The study provides insights into how to develop a more holistic and unified understanding of NOE by exposing pre-service teachers to FRA-related engineering concepts.

The Engineering Design Efficacy Journey of Novice Science Teachers

Laura Wheeler*, Brigham Young University, USA
Max Longhurst, Utah State University, USA

ABSTRACT

Science educators are tasked with enacting The NGSS, including engineering core ideas and practices. Teacher preparation programs may not include engineering design units or courses, leading many science teachers to believe they are unprepared to teach engineering design. A lack of engineering design teaching self-efficacy may result from little experience and the belief of being unprepared to teach engineering design. This mixed-method case study researched the engineering design teaching self-efficacy of eleven preservice educators during an engineering design unit taught in a science methods course. Researchers described the changes in preservice educator self-efficacy over the development and delivery of an engineering design unit. The analysis revealed that engineering designs teaching self-efficacy beliefs developed over time with wavelike fluctuations. Preservice educator engineering design teaching self-efficacy progressed from onset, developing, emerging, to maturing stages. Fluctuation in efficacy was consistent with progression if preservice educators received mentorship to facilitate sensemaking through the process of pedagogical task analysis. To reach the efficacy maturing stage, teachers need the autonomy to enact engineering design curricula aligned to content standards. A description of engineering efficacy is expected to assist professional learning instructors and curriculum developers in increasing enactment of engineering design in secondary science classrooms.

Preservice Science Teachers' Development in Understanding the Relevance of Scientific and Engineering Practices

Young Ae Kim*, Defense Language Institute, USA
Michele Korb*, CSU East Bay, USA

ABSTRACT

This qualitative study examines preservice science teachers (PSTs) shifts in facilitating Scientific and Engineering Practices (SEPs) during their teacher education program. The study narrows the analysis of pre-post reflections for SEP4 (analyzing and interpreting data) and SEP6 (constructing explanations). PSTs utilized a SEP toolkit containing leveled guidelines for teachers aimed at facilitating discourse and implementing the SEPs. This study aimed to characterize the PSTs' attention to and understanding of ways for facilitating student engagement in SEP4 and SEP6. The analysis indicated that initially most PSTs made general comments on student actions and paid attention to task management rather than focusing on specifics of SEPs or student intellectual involvement. Over time, PSTs included more specific skillsets within the SEPs (e.g., organize and display data in SEP4 analyzing and interpreting data), but some skills were rarely observed (e.g., use statistical techniques to analyze data). Further, PSTs included more descriptions reflective of 'teacher as a facilitator' in post-reflections. Very few PSTs described how to facilitate student engagement of SEPs using tangible examples, whereas most lacked concrete application of SEPs skills. We suggest alternative avenues to promote PSTs' learning of SEPs to engage students in the intended intellectual work.

Scientific Thinking Beyond Science Contexts: Everyday Science as a Frame Beyond Labs and Classrooms

Bryan Nichols*, Florida Atlantic University, USA

ABSTRACT

Thanks in part due to conflicting and confusing portrayals of science in popular media, many educators and students struggle to effectively understand and use scientific thinking. This presentation will introduce NARST members to everyday science, a more structured framework for teaching and learning about science that incorporates aspects of NOS and the NGSS practices, complements local content standards, and explicitly incorporates affective and moral elements. Although it begins simply, everyday science is pedagogically and theoretically rich enough to build a relatively sophisticated understanding of the nature of science and how scientific thinking can be helpful well beyond traditional science contexts. The framework consists of three domains: concepts, skills, and attitudes. Concepts includes NOS and crosscutting concepts from the NGSS but defers to discipline-based local standards for details. Skills includes basic, integrated, and social skills that form a flexible tool kit for scientific investigation. Finally, everyday science includes a set of attitudes to promote scientific thinking in ways that expand it (e.g., curiosity, creativity), but also focus it (e.g., persistence, skepticism, honesty, respect). The presentation will include the analysis of results from a helpful journaling assignment that helps educators describe, model, and nurture scientific thinking beyond classrooms and labs.

Strand 7: Pre-service Science Teacher Education

SC-Organized Paper Set

Research Investigating Competency in Preparing Preservice Teachers and Teacher Educators

20-Mar-24, 11:00 AM-12:30 PM

Location: Governor's Square 14

Can STEM and non-STEM Major Preservice Teachers Acquire Same Teaching Competence From STEM Method Course

Hsiao-Lin Tuan*, National Changhua University of Education, Taiwan
Chi-Chin Chin, National Taichung University of Education, Taiwan

ABSTRACT

The purposes of this study were to examine the effectiveness of STEM teaching method course on STEM and non-STEM preservice teachers' teaching competence, to explore whether there is any difference between these two groups teaching competence, and to examine these preservice teachers' STEM lesson plans. We collected data of preservice teachers participated in three semesters of 18-week STEM teaching method course. One group pre-post test design was used in the study, all preservice teachers have to fill in Teachers' Perception of STEM teaching competency [TPSTEMTC] questionnaire in the beginning and at the end of semester. We also collected and analyzed preservice teachers' final project-STEM lesson plans. Finding indicated that 135 preservice teachers after taking our course, their perceptions of STEM nature, STEM teaching preparation, STEM curriculum design, STEM teaching activities implementation, and expectation of STEM teaching outcome all increased significantly in the post test. STEM major (n=47) and non-STEM major (n=88) showed significant difference only on STEM teaching implementation activities. These preservice teachers' lesson plans covered science inquiry and engineering design process, but few covered on math. Implication for teacher education will be discussed in the paper.

Becoming a Globally Competent Educator: Self-Study of My Theoretical and Practical Understanding of Global Competency.

Arya Karumanthra*, Indiana University, USA
Gayle Buck, Indiana University, USA

ABSTRACT

This self-study explored my theoretical and practical understandings of my role and responsibilities regarding preparing future science educators that are globally competent. Specifically, I focused on how I changed my approach to teaching and addressing global competencies during science instruction as an elementary science teacher educator. Using grounded theory, open coding, and the constant comparison method allowed for a comprehensive and rigorous data analysis, including journal entries, critical friend meetings, concept maps, and student artifacts. The findings and subsequent implications inform the field of science education regarding teacher educators' role in preparing teachers to be critical change agents.

Evaluating Questioning Competency in Elementary Pre-Service Teachers Using Likert-Scale Questions

Jianlan Wang*, Texas Tech University, USA
Shahin Kashef, University of Georgia, USA

ABSTRACT

Questioning is a critical learning objective for pre-service teachers (PSTs), yet there is a lack of quantitative instruments measuring PSTs' competencies of questioning. Questioning from PSTs is mainly examined using qualitative approaches, like discourse analysis. While this method yields rich information, it becomes unwieldy for conducting large-scale analyses involving numerous PSTs. In our previous study, we designed and validated an instrument of

free-response questions that measure PSTs' competencies of asking effective guiding questions to address students' difficulties regarding different science content. In this study, we explored an alternate approach by converting free-response questions into Likert-scale questions. PSTs' pedagogical content knowledge of questioning can be derived from their rates of items that represent different competencies of questioning. We will introduce the instrument of Likert-scale questions, present the data about its validity and reliability, and discuss its use in science teacher preparation.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Exploring Science Aspirations, Process Skills, and Capital Across Sociocultural Contexts
20-Mar-24, 11:00 AM-12:30 PM
Location: Governor's Square 15

Differences in Science Expectancy-Value Beliefs and STEM Career Pathways by Rurality
Guan Saw*, Claremont Graduate University, USA

ABSTRACT
Analyzing the nationally representative High School Longitudinal Study of 2009, this study examines the rural-nonrural disparities in science expectancy-value beliefs, and differential relations between science expectancy-value beliefs and STEM career aspirations and STEM college major by rurality. This study is one of the first to empirically tests the applicability of situated expectancy-value theory (SEVT) in the domain of science across rurality (rural vs. town vs. city vs. suburban) with a nationally representative longitudinal sample of high school students, which allows greater generalizability. It documents that rural high school students showed lower levels of science expectancy belief and utility value, compared with their suburban and city peers, respectively. This study also find that for both rural and nonrural students, all four expectancy-value beliefs in science (i.e., science expectancy belief, interest, attainment value, and utility value) were individually predictive of both STEM career aspirations and STEM college enrollment. Of the four science expectancy belief factors, science attainment value is the strongest predictor of both STEM career aspirations and STEM college major for both rural and nonrural groups. The findings confirm the applicability of SEVT in science across rurality, which can enhance researchers' confidence in employing SEVT in rural science education research.

Reclaiming Missed Opportunity: Reflections on the Influence of Culture on Development of Science Process Skills
Peter Okebukola*, Lagos State University, Nigeria
Moses Emmanuel, Lagos State University, Nigeria
Atinuke Adekoya, Lagos State University, Nigeria
Joshua Akinpelu, Lagos State University, Nigeria
Ann Itodo, Lagos State University, Nigeria
Abdulazeez Balogun, Lagos State University, Nigeria

Modupe Omokongbe, Lagos State University, Nigeria

ABSTRACT
Two questions were of interest in this study: (a) How do Nigerian secondary school students perform in process skills of observing, classifying and predicting? (b) What impact has religion, ethnic affiliation, rural-urban culture and socio-economic status on the development of science process skills of observing, classifying and predicting? Fifty-nine students in junior and senior secondary schools in Lagos, Nigeria aged between 12 and 17 years participated in the study. A practical task was designed to measure observation, classification and predicting. Students performed relatively well on the observation task (mean of 78.4%) and less well on the classification task (63.7%). The least performance was on the prediction task (45.3%). Ethnicity combined with rural/urban domicile was found to play a role in observation. Religious affiliation exerted noteworthy influence on predicting. The findings of the study draw attention to the need for sensitivity to socio-cultural orientations of learners while designing interventions to bolster process skills. In the quest to reform STEM education, due notice must be paid to the role of culture in impacting how students acquire knowledge, practical skills (including process skills) and scientific attitudes.

A Theoretical Framework To Understand The Effect of Cultural Context On Immigrant Students' Science Attitudes
Havva Gorkem Altunbas*, UCL - Institute of Education, United Kingdom

ABSTRACT
I introduce a new theoretical framework for investigating the impact of cultural backgrounds on the attitudes of immigrant students towards science. By fusing Self-Determination Theory with Bourdieu’s capital framework, my goal is to unveil how cultural factors impact immigrant students’ science aspirations. Combining a sociocultural and motivational perspective, this framework enables to look at these students’ attitudes towards science from broader and multiple perspectives. The theoretical framework consists of two phases. The first phase draws a path to examine immigrant students’ current intrinsic motivations based on their perceived autonomy, relatedness and competence. The second phase investigates how these students’ attitudes toward science are shaped by their cultural and social capitals. This theoretical framework serves as the foundation for my PhD research focused on understanding the attitudes of immigrant students towards science within the context of England.

Strand 11: Cultural, Social, and Gender Issues
Symposium
Indigenizing STEM Within Teacher Education and Professional Development
20-Mar-24, 11:00 AM-12:30 PM
Location: Governor's Square 17

Indigenizing STEM within Teacher Education and Professional Development
Julie Robinson*, University of North Dakota, USA

Rebekah Hammack, Purdue University, USA
Paichi Shein, National Sun Yat-sen University, Taiwan
Agnes Ahanonye, University of The Witwatersrand, South Africa
Bhaskar Upadhyay, University of Minnesota, USA
Pauline Chinn, University of Hawaii at Manoa, USA
Lenora Crabtree, University of North Carolina Charlotte, USA

ABSTRACT
Teacher professional development rarely focuses on developing teachers' competency in local Indigenous cultures to prepare them to embed instruction and pedagogy that best facilitates the engagement and achievement of their diverse students. This is particularly impactful within STEM domains, where prior science and engineering instruction has often been decontextualized and presented as acultural, which is in direct contrast to the epistemological orientations of Indigenous students. A limited body of literature that explores the experience of non-Indigenous teachers within Indigenous educational contexts suggests that on-going professional development in which cross-cultural dialogue, sharing, and intentional engagement with community partners and stakeholders from the local culture are essential components of transforming teachers' practice. The purpose of this symposium will be to share methods and outcomes of projects being conducted across diverse communities and regions of the world that are aimed at providing professional development in culturally sustaining approaches to STEM education for non-Indigenous educators who teach in schools with high populations of Indigenous students.

Presentations:

Julie Robinson, Frank Bowman, Bethany Klemetsrud, University of North Dakota
Project ExCEED - Using a Culturally Relevant Engineering Design (CRED) Framework within Teacher Professional Development
Rebekah Hammack, Purdue University; Paul Gannon, Montana State University; Nick Lux, Montana State University
Culturally Relevant Engineering Research Experiences for Elementary Teachers
Paichi Pat Shein, Peresang Sukinarhimi, Tzu-Yu Kuo, National Sun Yat-sen University
Building family partnerships for school-wide integration of Indigenous STEAM
Agnes Ahanonye, University of The Witwatersrand
Pre-service Science Teachers' Indigenous Identity and the Affordances of Integrating Indigenous Knowledge in their science classrooms
Bhaskar Upadhyay, University of Minnesota
Indigenous Cultural Heritage in the Making of STEAM Education for Sociopolitical Consciousness: A Case of Teacher Development in Nepal
Pauline Chinn, Alison Yasuoka, Kaleolani Hanhano, Ruben Juarez, Binh Le; University of Hawai'i at Manoa
The Role of Teachers as Public Health Educators
Lenora Crabtree, University of North Carolina Charlotte
Lessons from a Lost Practice

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set
History of Science
20-Mar-24, 11:00 AM-12:30 PM
Location: Plaza Court 3

Explicit NOS Instruction in Chemical Experiments using Reflective Scientific Inquiry and History of Science Approaches

Janne-Marie Bothor*, University of Kassel, Germany
David-Samuel Di Fuccia, University of Kassel, Germany

ABSTRACT
The use of experiments in chemistry lessons is often aimed at imparting content and procedural knowledge. To gain an authentic understanding of science, experiments can be used to explicitly reflect on NOS aspects. For this purpose, experiments were designed in a university learning environment with 7 pre-service science teachers, which are intended to impart epistemic knowledge based on selected NOS aspects using a Scientific Inquiry or a History of Science approach. For this purpose, the participants have developed teaching concepts and material, which will be used in this study for the evaluation and analysis of the objectives, as well as the problems and difficulties. In addition, test tasks were carried out, which evaluate the work process of the participants and are also evaluated in this study. The results show that the participants succeed in explicitly-reflectively instructing NOS aspects in experiments, but that the epistemic NOS aspects are often confused with content knowledge and that the focus on promoting NOS only succeeds in an extensive work and reflection process of the pre-service science teachers. In addition, it could be shown which NOS aspects are preferred in a Scientific Inquiry and which in a History of Science approach.

Unraveling the Fictionalized Ideal: The Evolution of "The" Scientific Method in the 19th Century

Farnaz Avarzamani*, Arizona State University, USA
Mila Rosa Carden, University of North Texas, USA
Peter Rillero, Arizona State University, USA
Samira Golshani, Islamic Azad University, Islamic Republic of Iran

ABSTRACT
The Scientific Method (TSM) has been proffered as the entity that makes science special, and thus scientifically derived knowledge is very valuable, the pursuit of science is justifiable, and science education with TSM is desirable. Contemporary authors have suggested that TSM is a fictionalized ideal, yet the term is still used in education. TSM had a powerful influence on science, society, and science education. Through the application of content analysis, we delved into the emergence, evolution, and co-occurrence of TSM usage alongside other terms during the 19th century. We found that TSM was used more in the second half of the century in non-scientific fields, especially religion.

Impact of Historical Science Stories on Post-Secondary Students' NOS Understanding and Attitudes Toward Science

Michael Clough*, Texas A&M University, USA
Benjamin Herman, Texas A&M University, USA
Alex Sobotka, Texas A&M University, USA
Alister Olson, Texas A&M University, USA

ABSTRACT

Attention to HNOS teaching and learning has appeared in science education reform and standards documents since at least the late 1980s (AAAS, 1989, Achieve, 2013; NRC, 1996; McComas & Olson, 1998; Olson, 2018). Despite the agreed upon importance of accurate HNOS understanding for science literacy, and its role in more informed SSI decision-making, conceptually understanding particular science ideas, and improving science attitudes, efforts aimed at encouraging teachers to devote explicit attention to NOS instruction have largely been disappointing. Teachers at all levels generally disregard the HNOS as an overt learning outcome (Abd-El-Khalick et al., 1998; Lederman, 1998), perhaps primarily because they see it as significantly less important than science content teaching and learning. Short historical science stories targeting fundamental science ideas that instructors can infuse when and where they deem suitable may present a viable approach to this concern. We report here the impact of five historical stories on students' NOS conceptions in a large introductory post-secondary majors' biology course at a research-extensive university. The short stories had positive impacts on students' understanding of the NOS, interest in science careers, and interest in science content.

Interaction of History and STEM Learning Goals in Teacher-Developed Curriculum Materials

Wonyong Park*, University of Southampton, United Kingdom

ABSTRACT

Although the integration of subjects across the curriculum has been advocated in recent years, there are limited opportunities for teachers of different subjects to collaboratively implement integrated curricula in schools. This study considers history as a humanities subject that could be integrated with STEM and explores the diverse history-related learning objectives found in teacher-developed STEAM curriculum materials. Using integrated STEAM curricula developed by 13 cross-curricular teacher teams, I analyze the history-related learning goals presented in the curricula. First, the majority of the curricula aimed for students to identify themselves in their regional and national history, but other levels of identification were also targeted. Second, all of the curricula included goals related to historical analysis, sometimes integrated with scientific inquiry skills. Third, I found several goals related to eliciting students' moral response to history, especially when the curriculum topic involved issues at the national level. Fourth, the integration of subjects allowed for the display of students' historical understanding through various activities and in explanatory, persuasive, and imaginative forms. Overall, the analysis pointed to several ways in which the goals of history learning can interact with those of STEM learning, which may be useful for future research and practice in curriculum integration.

Strand 14: Environmental Education and Sustainability
Related Paper Set
Science Teacher Education Towards Environmental Justice: Approaches, Strategies and Frameworks
20-Mar-24, 11:00 AM-12:30 PM
Location: Plaza Court 8

Centering Aina-Based [land, earth] Education in Place-Based STEM Instruction
Tara O'Neill*, University of Hawaii at Manoa, USA

ABSTRACT
This paper explores what it means to center __ina-Based [land, earth] education in place-based STEM instruction through the STEMS2 Framework. This framework was designed over 13 years of critical ethnographic case studies combined with a design process grounded in agile design methodology with a network of 32 educators from diverse backgrounds. Data collected included community partner interviews, teacher interviews, classroom and community observations, student and teacher work samples, and talkstory interviews. The STEMS2 Framework exists in three parts: Theory, Pedagogy, and Network. STEMS2 Pedagogy is rooted in connecting with communities, learning from the place, the people, the kupuna [ancestors], and the mo_olelo [stories]. Participants describe the application of STEMS2 Pedagogy as a process of decolonizing instruction. For some, decolonizing means centering Native Hawaiian knowledge in their Science and Engineering courses. The result is an emphasis on place-based content while building relationships with community partners. The practice requires (1) connecting to ‘aina [land, earth], (2) broadening the scope of what ways of knowing, discourse, and practices are valued in the curriculum, (3) expanding the definition of expert, and (4) redefining success. For all, the process of engaging with the STEMS2 Framework is met with empowering successes and systemic roadblocks.

Double Stimulation: Repositioning Preservice Elementary Teachers as Agents of Social and Environmental Justice
Jenny Martin*, Australian Catholic University, Australia

ABSTRACT
This paper explores andragogy informed by Vygotsky’s principle of double stimulation mediated preservice teacher (PSTs) agency concerning environmental justice. Over the course of a 12-week semester, approximately preservice teachers conducted an inquiry into their own practices, known as the Eco-Challenge, act to reduce their ecological footprint and submit an evidence-based evaluation of their new practices. Conceived of as an interactive ethnography, data for the study were derived from planning documents, the teacher educator’s field notes, and PSTs’ reflective journals. Twenty journals were selected randomly from around 200 PSTs who had provided their informed consent. The journal entries were analyzed as written acts, i.e., written for a communicative purpose, and coded according to the PSTs’ self-positioning. Analysis showed two kinds of self-interventions. Firstly, the PSTs took action towards environmental justice to varying degrees and, secondly, the PSTs took

action to alter the kind of person they took themselves to be. The research illustrated the potential of double stimulation for supporting practice in ITE that can promote activism. Further, the articulation of andragogical principles grounded in cultural-historical psychology has the potential to support practice development in initial teacher education and will be of interest to educators and researchers.

Art and Science-based Cyanotype Experiences Help Promote Environmental Awareness and Stewardship in Pre-service Teacher Training

Maraliz Fischler-Barraza*, San Diego State University, USA

ABSTRACT

Environmental injustice consistently and disproportionately affects minoritized communities. To move towards a more just education system, future teachers must be prepared to become environmental stewards within their communities. Through this project, I focused on exploring how art and science-based activities in science methods classes support educators in becoming environmental stewards while providing tools to engage responsibly with their environment and support environmental justice in their classrooms. Specifically, I focused on investigating in what ways the art and science-based activity of cyanotyping supports pre-service teachers in engaging students in environmentally-just science education and how pre-service teachers learn about environmental justice as they engage in cyanotyping. This paper discusses the submitted work of 13 pre-service teachers (PST) participating in an elementary science methods course for their teacher credentialing program. The results indicate that cyanotyping provided opportunities for PST to engage in creative science-based activities that facilitated collaboration, exploration, design, and discussion. Further, the data supports that cyanotypes support PSTs to explore and observe their environment while using their bodies, as well as discarded organic materials, to create artistic representations of their surroundings. Together these activities help promote environmental awareness and stewardship among PSTs.

Children Leveraging Science Practices, Care and Expertise towards Hyperlocal and Global Climate Justice

Kathleen SChenkel*, San Diego State University, USA
Cassie brownell, University of Toronto, Canada
Jon Wargo, University of Michigan, USA

ABSTRACT

We explored in a multi-site case study: 1) How do children engaging integrated art, science, and literacy-focused curiosity walks a) cultivate and b) communicate their understanding of their coastal community dynamic ecosystems? and 2) How do children's understanding of climate justice at the local and global evolve across four local seasonal curiosity walks and four Zoom sessions with children from three different geographic regions?
Over 150 children, in grades 1st through 6th, participated in an at-home art, science, and literacy program focused on supporting children and their families in exploring their coastal climates. This paper investigates the four curiosity walks that children engaged in with their

families and four Zoom conference sessions with other children across three different coastal regions.
Guided by Cultural Historical Activity Theory (CHAT), our findings are:
1) Crafting representations of their noticings and wonderings from family walks in their ecological communities supported children to a) analyze the interactions within ecosystems and b) express concern and care for the natural world as they c) engaged in the science practice of asking questions.
2) Communicating their new understandings with peers across coastal communities supported children in deepening their understanding of climate justice at a local and global level.

Strand 3: Science Teaching — Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set
Supporting Diverse Science Instruction
20-Mar-24, 1:45 PM-3:15 PM
Location: Plaza Court 2

Elementary School Teachers' Use of Educative Support Curricula: Citizen Science Projects in Science Instruction
Sarah Carrier*, North Carolina State University, USA
Patrick Smith, Horizon Research, Inc., USA
Jill McGowan, North Carolina State University, USA
Lindsey Sachs, Horizon Research, Inc., USA
Meredith Hayes, Horizon Research, Inc., USA
Sarah Safley, Horizon Research, Inc., USA
Chris Goforth, North Carolina Museum of Natural Sciences, USA
Danielle Scharen, Horizon Research, Inc., USA

ABSTRACT
Science instruction is an important part of a complete education experience beginning in primary grades, yet currently the frequency and depth of science instruction in elementary schools pales in comparison to mathematics and reading instruction. In addition to time constraints, teachers report a lack of resources for science instruction, including curricula, and some teachers have chosen to enhance their science instruction by introducing students to citizen science (CS) projects. When CS projects are incorporated in formal school settings, students have an opportunity to engage in real-world projects as they collect and make sense of the data, yet few CS projects offer curriculum support for educators. Our research team developed educative support curricula, designed to support both student and teacher learning, for two CS projects. We present quantitative and qualitative data that document elementary school teachers' use of the materials to learn how and what types of support materials promote teacher and student learning. We frame our research in theory on teachers' interactions with curriculum, and we describe the contributions of various features

that can help teachers' science instruction, including supporting their incorporation of CS projects in science instruction.

Exploring the Complexity of Teacher Development for Adaptive Teaching in Science Education

Jee Kyung Suh*, University of Alabama, USA
Jale Dursun*, University of Alabama, USA
Ercin Sahin, University of Iowa, USA
Brian Hand, University of Iowa, USA
Gavin Fulmer, Northwest Evaluation Association, USA

ABSTRACT

This study explores the complexity of teacher development for adaptive teaching in science education. To address the new vision of the Next Generation Science Standards, teachers require Adaptive Teaching Expertise (AdTex) to align curricula, interactions, and pedagogical approaches with the fundamental principles of the NGSS. Given the intricate nature of AdTex development, influenced by experiences, beliefs, and context, complexity mapping was employed to examine teacher development dynamics. The study delves into teachers' orientations, knowledge, and practices to enhance AdTex development for knowledge generation. The study underscores the significance of philosophical orientations, particularly ontology, and axiology, in shaping adaptive teaching and influencing the use of language, dialogue, and argument. This research informs NARST members about the intricacies of AdTex development, offering evidence-based approaches to enhance science education outcomes. It highlights the practical translation of philosophical orientations into classroom practices and their impact on adaptive teaching. By shedding light on AdTex's dynamics, the study aids teacher training and classroom optimization, ultimately enhancing knowledge generation in science education.

Supporting Elementary Teachers' Use of Culturally Responsive Pedagogy with Scenario-Based Performance Tasks

Jamie Mikeska*, ETS, USA
Jessica Tierney, ETS, USA
Niki Kanagaki, ETS, USA
Pamela Lottero-Perdue, Towson University, USA
Alessia Marigo, ETS, USA
Tricia Maxwell, ETS, USA
Katie Miller, Lawrenceville Elementary, USA
Devon Kinsey, ETS, USA

ABSTRACT

The study's purpose was to examine the potential of scenario-based performance tasks to provide a practice space where preservice and in-service teachers can develop their ability to engage in culturally responsive pedagogy (CRP) in elementary science. In this study, our research team piloted 13 CRP science tasks with 20 teachers (11 preservice and nine in-service). This examination used survey data to explore the teachers' perceptions about the

CRP tasks and used task-specific evidence inventories and a three-level scoring rubric to examine the nature of teachers' responses in terms of how well the teachers addressed key aspects of the Next Generation Science Standards (NGSS), the Culturally Responsive Teaching (CRT) framework, and the Work of Teaching Science (WOTS) framework. Findings suggest that most participants perceived the CRP tasks to address important science teaching knowledge, skills, and abilities that are critical for being an effective science practitioner. In terms of the nature of the teachers' responses to these CRP tasks, findings showed that, on average, teachers tended to score in the developing practice range for addressing all three aspects. Implications for how these CRP tasks could be used in both elementary science methods courses and professional development settings are discussed.

The Role of Curriculum Materials in Supporting Science Talk in K-2 Classrooms
Amelia Gotwals*, Michigan State University, USA
Tanya Wright, Michigan State University, USA

ABSTRACT
A focus of early elementary science is to support children in making sense of phenomena that are meaningful and interesting to them. However, shifting to this type of instruction may be challenging for elementary teachers, who have few resources to support them. In this study, we engaged in design-based research focused on developing supports for teachers to enact high quality science talk in kindergarten-grade 2 (K-2) classrooms. We examined two cohorts of teachers receiving the same PD, Cohort 1 used their business-as-usual science curriculum while teachers in Cohort 2 used the [Name blinded] curriculum. The cohort design allowed for quasi-experimental comparison to see whether changes made between iterations enabled teachers to enact higher quality science talk. We coded videos of instruction based on science talk and using regression analyses, we found significant effects in favor of Cohort 2 on the overall quality of science talk in K-2 classrooms (_ = .44, p <.001). We provide more nuanced results and illustrations of the types of talk in the classrooms. In alignment with recent research on professional learning, we find that elementary teachers may need both supportive curriculum materials and professional development to enact new and complex types of talk.

Strand 4: Science Teaching — Middle and High School (Grades 5-12): Characteristics and Strategies
SC-Organized Paper Set
Teachers' Use of Curricular Resources
20-Mar-24, 1:45 PM-3:15 PM
Location: Directors Row I

The Effect of Intervention Coursework on Science Achievement
Kristin Mansell*, Texas Tech University, USA

ABSTRACT
With the rising number of students serviced within the RTI model as well as students categorized with a special education disability, there has been an increasing need to enroll struggling students in intervention courses in tandem with their general education coursework requiring those struggling the most with academics to have additional academic focused courses than capable peers. Though the needs of special education students have been of a particular focus for researchers, those struggling students without a special education designation remain untapped in terms of evidence for student outcomes when serviced under RTI tiers in intervention courses. Therefore, this study uses propensity score matching to determine the association between outcomes on the Texas STAAR 8th grade end of level test and STAAR Biology end of level test of students enrolled in only general course work, intervention courses, or science intervention courses to determine best placement for students within the RTI model. In addition, this study analyzes student characteristics, specifically teacher preparation pathway, to determine teacher effectiveness in teaching intervention courses for science student outcomes.

Practitioner-reported Needs for Enacting, Implementing, and Adopting OpenSciEd Curriculum Materials

Kevin McElhaney*, Digital Promise, USA
Rochelle Urban, Digital Promise, USA
Danae Kamdar, Digital Promise, USA

ABSTRACT
OpenSciEd is a set of open and freely available curriculum materials addressing the Next Generation Science Standards. OpenSciEd's distinctive affordances and widespread adoption uniquely enables researchers to address important knowledge gaps in science education. OpenSciEd's ambitious vision gives rise to opportunities to support teachers and education leaders with classroom enactment, professional learning, and school or district adoption. This study examines the areas of support that practitioners deem to be most urgent. We identified 22 challenges related to classroom enactment, teacher support, system factors, and equity based on existing research literature. We administered an online survey to 128 teachers and leaders who rated how often they experienced these challenges, identified up to 3 challenges as high priority, and identified student groups who experienced equity challenges. Four themes emerged from the analysis: sustaining student engagement, access to planning and reflection time, assessment, and meeting the needs of specific student groups. We also found differences in the types of support needed across practitioner groups and contexts. Findings point to new research and innovation opportunities that can support OpenSciEd practitioners.

Early Career Science and Mathematics Teachers' Access to and Use of Resources

Robert Idsardi*, Eastern Washington University, USA
Shannon Navy, Kent State University, USA
Julie Luft, University of Georgia, USA
Lisa Borgerding, Kent State University, USA
Ella Yonai, University of Georgia, USA

Emily Hamada, Eastern Washington University, USA
Adepeju Prince, Kent State University, USA
Kelly Kulp, University of Georgia, USA
Elizabeth Ayano, University of Georgia, USA
Jose Pavez, Western Illinois University, USA

ABSTRACT
Early career science and mathematics teachers are most vulnerable to attrition. Social, material, and human resources can address attrition. This study describes the resources that early career science and mathematics teachers in high needs schools have access to and use over an academic year. This project was framed by the Conservation of Resources (COR) theory and used quantitative observation methodology. Participants include early career science (n = 22) and mathematics (n = 4) teachers in their first five years of teaching. Teachers reported their access to and use of social, material, and human resources through electronic surveys at the beginning, middle, and end of the 2022-2023 academic year. We used repeated measures ANOVAs to determine if teachers' access and use of resources changed across the year and a hierarchical cluster analysis to identify patterns of resource use. Teachers did not gain or lose access to resources over the year, but the frequency of use of resources varied across different groups of teachers. This study contributes towards understanding the resource use of teachers and suggests that additional studies are needed that explore the relationship of resources to one another, and their potential connection to the attrition and persistence of teachers.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set
Advancing Assessment Literacy and Pedagogical Practices
20-Mar-24, 1:45 PM-3:15 PM
Location: Governor's Square 12

Measuring Assessment Literacy of STEM Faculty in Higher Education: A Systematic Review
Mikayla Strasser*, University of Illinois Chicago, USA
Yue Yin, University of Illinois Chicago, USA

ABSTRACT
This paper presents a systematic review of assessment literacy instruments in higher education, particularly STEM. Assessment literacy involves educators' understanding of valid and reliable assessment principles for informed instructional decisions. One way to address disparities in underrepresented minority student outcomes in STEM, is for universities to create supportive classroom environments with diverse assessments. Universities can foster this by providing targeted professional development to improve faculty assessment literacy. To accomplish this, strong measurement instruments are needed. Through reviewing a sample of 28 empirical articles, we identified primary instruments and measured constructs, including instruments adapted from K-12 contexts. Findings reveal gaps in comprehensive

assessment literacy instruments for STEM higher education, highlighting the importance of enhancing faculty's assessment literacy for improved student outcomes.

Prospective Elementary Teachers' Written and Pictorial Images Representing Observations and Inferences of a Puzzling Phenomenon

Jaclyn Murray*, Mercer University, USA

ABSTRACT

Prospective elementary teachers have difficulty delineating between observations and inferences; thus, they are more likely to pass these misconceptions on to elementary students. In this study, we seek to uncover prospective elementary teachers' ways of conveying observations and inferences while constructing an initial model to explain (ideas about what causes the phenomenon before investigation; they have no evidence yet) a scientific phenomenon. We found differences in the way prospective elementary teachers communicate their observations and inferences in a physical science course for teachers in the context of constructing model-based explainations of scientific phenomenon. Our study contributes to the science teacher content knowledge literature centered on embedded formative assessment at the beginning of a phenomenon-based unit.

Effects of Learning Assistant Facilitation on Student In-the-Moment Learning

Nicolette Maggiore*, Tufts University, USA
Ira Caspari-Gnann, Tufts University, USA

ABSTRACT

Introductory STEM courses are often taught with learning assistants (LAs), i.e., undergraduate students who have taken the course before and facilitate discussions in small groups of students during active learning. Using LAs leads to improved student learning outcomes, however, little is known about how LA facilitation practices influence the progression of student learning and thus lead to these improved outcomes. We combined two sociocultural frameworks to characterize LA actions as authoritative (centering the canonically correct or LA perspective) or dialogic (centering students' perspectives) and investigate how these actions influence students' in-the-moment learning conceptualized as the noticing and filling of needs in discourse. Our study reveals the following: LA actions had five similar, broader effects on student in-moment learning, while a deeper look into authoritative and dialogic facilitation demonstrates variations in how these effects played out during interactions. We provide examples of these similarities and differences to demonstrate how various LA facilitation moves can induce and fulfill similar needs within an interaction along with how the perspectives centered by LAs during their facilitation impact the ways in which these needs are met. Implications for faculty and LA training, along with course design, will be discussed.

Tertiary Engineering Faculty's Journey to Active Learning Pedagogies through Lesson Study

Cynthia Gibson, University of Texas at San Antonio, USA
Elizabeth McMillan*, University of Texas at San Antonio, USA
Juliet Langman, Kennesaw State University, USA

Jorge Solís, University of Texas at San Antonio, USA
Janeth Martinez-Cortes, University of Texas at San Antonio, USA

ABSTRACT
The goal of this study is to understand how undergraduate engineering instructors make sense of and operationalize active learning in traditional lecture contexts as a result of their participation in a collaborative professional development project involving faculty from engineering and education. We present a comparative case study of two instructors who participated in a longitudinal research project utilizing an adapted lesson study (LS) model to redesign STEM lessons aimed at improving student achievement and retention outcomes at a Hispanic Serving Institution. Thematic analysis of discourse during LS meetings and lesson implementation reveal that engineering instructors undertook their own active learning process to adapt pedagogical approaches to integrate active learning in introductory courses and recitation sessions. Shifts in their actions and discussions that demonstrate orientation toward active learning include assessment of the logistics involved in active learning lessons, strategic planning and reflective evaluation of activities that ensure equitable participation and robust discussion during activities, and dialogue about the perceived benefits of integrating active learning for improving student academic experiences. Interdisciplinary collaboration in tertiary STEM education can lead to improved pedagogical knowledge and integration of active learning strategies with the potential to improve student achievement.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set
Developing STEM Identities and Feelings in Informal Learning Contexts
20-Mar-24, 1:45 PM-3:15 PM
Location: Governor's Square 11

Harnessing the Strengths of Young Black Girl's Feelings Towards Science from an OST Space
Heather Lavender*, University of Georgia, USA

ABSTRACT
From six weeks of science during an eight-week summer camp housed in the facilities of a local church, this study presents the views and perceptions of science from two middle school Black girls. An Out-of-School setting such as a summer camp provides a space for researchers to explore the impacts of science when carried out in different ways such that the teaching community may utilize the findings for in classroom practices. This study follows a single-case research design with multiple cases of 5th – 8th grade Black girls in an Out-of-School setting during a summer camp. The intentional inclusion of the participants' lived experiences into the summer science activities brought about family involvement, heightened interest and engagement to experiential learning, and authentic embracing to human experiences. Using Black girlhood studies as a lens enabled the joy and celebration of Black girls to be visible as they experienced science.

Future Teachers in the Making: Identity Development through Afterschool STEM Programming

Jasmine Nation*, California Polytechnic State University, San Luis Obispo, USA
Alexandria Hansen, California State University, Fresno, USA
Kristin Bridgeford, California Polytechnic State University, San Luis Obispo, USA
Jess Jensen, California Polytechnic State University, San Luis Obispo, USA
Katie Sinclair*, California Polytechnic State University, San Luis Obispo, USA
Myunghwan Shin, California State University, Fresno, USA
Isabella Contreras, California Polytechnic State University, San Luis Obispo, USA
Claire Gillaspie*, California Polytechnic State University, San Luis Obispo, USA

ABSTRACT

Researchers have clearly outlined how youth benefit from making in informal settings, but have less insight into supporting facilitators in these spaces. Therefore, we examined how participation in two afterschool maker programs impacted STEM identity development for youth, while also fostering teacher identity development for undergraduate facilitators. We applied a design-based research approach to analyze 90 field notes from 37 undergraduate participants in service-learning courses at two universities in California. We utilized Nasir and Cooks' identity resource model framework to document undergraduate facilitator experiences and perspectives, considering the material, relational, and ideational affordances and constraints for identity development. In our findings, we unpack how materials afforded new ways of viewing technology and connections to making and STEM, however also created constraints and led to frustration. Collaboration helped youth to problem solve and mentors to see themselves as teachers and reflect on their role as disciplinarians versus facilitators. Finally, we provided an illustrative example that showed the impact when these three resources were leveraged simultaneously. We concluded that the most powerful instances of identity development occurred when all three resources were leveraged simultaneously, increasing the sense of belonging for all participants.

Engaging in Scaffolded Outdoor Scientific Practices to Build Feelings of Being a Scientist

Kristy Daniel*, Texas State University, USA
Rachel Lincoln Seets, Texas State University, USA
Carolyn Jess, Texas State University, USA
Jill Zipperer, Texas State University, USA

ABSTRACT

It is well known that outdoor education can enhance student learning outcomes. Unfortunately, outdoor education is underutilized due to a variety of factors, including cost, access, supervision, and more. Our project sought to explore how using visual scaffolding might support learning and building feelings of being a scientist among elementary students through participating in a self-guided outdoor activity. We designed a quasi-experimental, qualitative investigation to document differences in student completion and comprehension of scientific process tasks and record what elements of the activity made participants feel most like a scientist. We found that the use of scaffolding allowed students autonomy while engaging with the activity and they were more likely to complete and

comprehend the content than if they were not provided with a scaffolded booklet. Also, we found that students most felt like scientists when they were provided with the opportunities to engage in observation practices, interpret visual data, and collect data outside in a fieldwork setting. Our project suggests that visual scaffolding design techniques can help teachers maintain the development of science practices outside while empowering students to act like scientists and investigate the outdoors independently.

Supporting Equitable Practice in Makerspaces: Learnings From Youth Programmes in the Global Makerspaces

Meghna Nag Chowdhuri*, University College London, United Kingdom
Louise Archer*, University College London, United Kingdom

ABSTRACT

The dominant contemporary makerspace movement originated within the 'global North' and espoused a rhetoric of democratising technology and innovation. This idea has gained traction leading to a proliferation of makerspaces both in global North and South contexts. While research shows that these spaces have the potential to support marginalised youth to develop and express their agency through making, there is also evidence that majority of makerspaces reproduce dominant ideas around what constitutes STEM knowledge and skills and who does STEM-rich making. This paper explores understandings and practices of global makerspaces as they implement equity-oriented ideas in their youth programmes. The paper draws from a two-year multi-site project based in 5 countries, and analyses data from 40 practitioner interviews and 33 youth workshop observations. The paper finds that meaning making around equity in these makerspaces differed between global North- and South-based makerspaces, highlighting the importance of considering contextual issues when setting up youth programmes in different makerspaces. While an underpinning politics of redistribution (of STEM resources and capital) was prevalent across all the makerspaces, its expression in practice varied considerably. The paper contributes to expanding our understanding of equitable practice in mainstream makerspaces that are bourgeoning across the globe.

Strand 7: Pre-service Science Teacher Education

Symposium

Teaching Science for Justice: A Case Study of Preparing and Supporting Teachers Across Three Years

20-Mar-24, 1:45 PM-3:15 PM

Location: Governor's Square 15

Teaching Science for Justice: A Case Study of Preparing and Supporting Teachers Across Three Years

Sinead Brien*, University of South Carolina Upstate, USA
Matthew Adams, Michigan State University, USA
Taylor Mackenzie, Everett High School, USA
Katelynn Jackson, Holt High School, USA

Nicole Hefty, Canal Winchester High School, USA

ABSTRACT
Over the last few decades, there has been an increasing focus on educational research that supports science teachers to teach in socially just ways. Unfortunately, the two-worlds pitfall suggests that novice teachers are not supported in navigating competing messages of what it means to teach from university-based teacher preparation programs and in-service K-12 schools (Braaten, 2019; Feiman-Nemser & Buchmann, 1983), and this complication often results in teachers shifting their practices away from those taught in their teacher preparation program (Smagorinsky et al., 2013; Johnson & Barnes, 2018). In this symposium, we explore the preparation and support of socially just novice science teachers in three ways. First, we examine how novice teachers established & articulated a clear framework of science teaching for justice. Second, we learn from three novice science teachers how they enacted practices in alignment with their framework. Third, we explain how these three novice science teachers took up and co-created supports from their teacher preparation program through their first year of teaching towards developing more socially just teaching practices.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
Mentoring and Empowering Teacher Leaders
20-Mar-24, 1:45 PM-3:15 PM
Location: Plaza Court 5

Mentor Teachers' Perceptions of Mentoring for Reform-Oriented Science Teaching Before and After Implementing Educative Mentoring

Amanda Hall*, North Carolina State University, USA
Grace Carroll, North Carolina State University, USA
Soonhye Park, North Carolina State University, USA
W. Matthew Reynolds, North Carolina State University, USA
N. Scott Ragan, North Carolina State University, USA
Jason Painter, North Carolina State University, USA

ABSTRACT
This qualitative research study explores the perceptions of experienced reform-oriented science teachers regarding mentoring practices aligned with educative mentoring practices. As science education shifts towards reform-oriented approaches, the study addresses the challenge of effectively implementing these approaches in the classroom. The study engages ten experienced biology and chemistry teacher mentors recognized for their constructivist and student-centered teaching methods. Through in-depth interviews conducted before and after educative mentoring professional development and subsequent implementation, the study examines how these mentors' perceptions of effective mentoring evolve and align with the principles of educative mentoring. Results indicate that these experienced mentors consistently emphasized the importance of relationships, alignment of teaching and mentoring, and commitment to the pedagogy. Furthermore, after applying the components

of educative mentoring to the mentor teachers' perceptions, it became evident that their views were inherently aligned with the educative mentoring model. The findings underscore the insights provided by the mentors' perceptions, contributing to a deeper understanding of the practical implementation of educative mentoring. The research's alignment of reform-oriented science teaching with educative mentoring emphasizes the significance of offering educators educative mentorship as they adopt new pedagogies, contributing to the evolution of effective support systems in science education.

Implementation of a Pilot STEMM Planning Institute for K-12 Campus Leadership Teams

Matthew Blank*, Baylor College of Medicine, USA
Alana Newell, Baylor College of Medicine, USA
Nancy Moreno, Baylor College of Medicine, USA

ABSTRACT

As science advances, there is a need to develop school pathway programs that support the development of learners' health literacy and skills needed to recognize and navigate difficult scenarios (e.g., disinformation, ethical use of AI) as they emerge, however there are few guidelines for school leadership teams to implement campus-wide science, technology, engineering, math, and medicine (STEMM) K–12 programming. This study investigates the implementation of a three-day STEMM Planning Institute for Leadership Teams to support preparation to include or refine STEMM programming. We developed a three-component framework —campus-specific planning using associated planning tools, professional development for teachers and leaders, and support for communities of practice—and investigate the value of these components and tools using pre/post-program surveys containing Likert-type items designed to measure participants' perceived changes in skills and abilities related to the planning institute's objectives. There were significant pre- to post-program gains for participants, highlighting the effectiveness of the planning institute. These results provide evidence for an applicable approach for campus and district administrators to address the health and biomedical sciences gap in K-12 education and to support learners' career pathway in the STEMM workforce, including learners from groups traditionally underrepresented in science and healthcare careers.

Science Instructional Coaches: Characteristics, Contexts, and Community

Emma Refvem*, Durham Public Schools, USA
M. Jones*, North Carolina State University, USA
Amber Meeks, North Carolina State University, USA
Tanzimul Ferdous, North Carolina State University, USA

ABSTRACT

Instructional coaching has emerged as a promising form of professional development for teachers. However, little is known about the background, contexts, professional responsibilities, and beliefs of instructional coaches that work with science teachers. This mixed-methods study focused on instructional coaches in secondary schools across the United States to understand what experience these coaches bring to the role and what activities they participate in that support science teaching. Coaches' goals for their work and tensions with the institution's goals were also explored. Results suggest that three types of coaches may support science teaching, depending on the content expertise of the coach (science or not) and the focus of their role (content-specific or general). Instructional coaches' support of science teaching is evident through their support of effective science teaching strategies. The goal of relationship building and the coaches' work as trust-builders emerged as a critical factor in the coaches' abilities to support teachers' pedagogical development. Implications for the field are discussed.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set
NGSS Practices and Pedagogy
20-Mar-24, 1:45 PM-3:15 PM
Location: Plaza Court 4

Leveraging Instructional Routines to Facilitate NGSS Implementation in High School Science

Elizabeth Chatham*, New Visions for Public Schools, USA
Angela Kelly, StonyBrook University, USA

ABSTRACT
This study employed a case-study approach to understand how teachers, who had participated in a sustained professional learning community, leveraged routines to implement NGSS-aligned instruction after the professional learning supports had been removed. The theoretical framework was drawn from studies that suggested high leverage practices, such as routines, can support ambitious teaching if embedded within professional learning that incorporates situated and proximate learning opportunities. Qualitative data were collected and coded for each of the three case study participants including individual interviews, focus group discussion, and transcripts of classroom observations. Findings indicated that the teachers believed the routines were supportive in increasing student engagement and equity and were valuable tools in NGSS implementation. However, little evidence was observed for the implementation of routines or NGSS-aligned instruction in two of the three cases. The lack of transferability of the routines to new contexts may be due to significant contextual barriers such as time constraints, lack of administrator buy-in, and the misalignment between the standards and high-stakes standardized exams. This suggests that critical barriers may lead to the compartmentalization of pedagogical beliefs when educators are facing pressures and messaging that lack coherence with the professional learning framework.

Exploring Teachers' Experiences with Implementing Open-ended Inquiry Labs in High School Physics Classes

Hamideh Talafian*, University of Illinois at Urbana-Champaign, USA
Maggie Mahmood, University of Illinois at Urbana-Champaign, USA
Tim Stelzer, University of Illinois at Urbana-Champaign, USA
Eric Kuo, University of Illinois at Urbana-Champaign, USA

Morten Lundsgaard, University of Illinois at Urbana-Champaign, USA
Devyn Shafer, University of Illinois at Urbana-Champaign, USA
Samuel Engblom, University of Illinois at Urbana-Champaign, USA

ABSTRACT
Investigation-style or open-ended labs in science can create pathways to experiencing authentic science learning for high school students. Even though many teachers acknowledge the importance of open-ended labs in students' science learning experiences, implementing these labs in high-school physics classes is challenging for teachers for a myriad of reasons. In this work, we present the results of three phases of data analysis including a retrospective survey and a case study. In addition to structural and perception-related barriers to students' abilities, the results showed another set of perceptions about teachers' abilities to implement open-ended inquiry labs in their classes. However, the retrospective survey data showed a collective change in perceptions, and a follow-up case study highlighted the pivotal role of physics teaching communities of practice in changing perceptions and shifting practices.

Cultural Historical Analysis of Teacher Reflections on Data Investigations of Extreme Weather in Rural Classrooms
Gili Marbach-Ad, University of Maryland, USA
Asli Sezen-Barrie*, National Science Foundation, USA
Josephine Louie, EDC, USA
Emily Fagan, EDC, USA
Brian Fitzgerald, Mount Washington, USA
Kevin Waterman, EDC, USA
Pam Buffington, EDC, USA

ABSTRACT
There has been a growing demand for proficiency in "data science" within contemporary scientific endeavors, while the use of authentic and complex data remains limited in science classrooms. This study uses the Cultural-Historical Activity Theory (CHAT) to explore the factors that affect integrating data investigations in science classroom activity on extreme weather events. Driving from multiple case studies of 6 rural science classrooms, we intend to answer the questions: What are the cultural and historical factors for integrating data investigations into rural science classrooms? and What contradictions for learning data science exist in rural middle-school science classrooms when investigating local extreme weather? The study's data sources include ~50 mins long teacher debrief interviews, implementation logs, and field notes from classroom observations. The constructs of the CHAT framework and constant-comparative approaches were utilized for the analysis of the data. The findings shed light on how CHAT can help understand cultural and historical dimensions of data integration that consider the repertoires of teachers and students. In addition, we report on contradictions teachers identified at the intersection of the following subcodes such as science concepts (tools) concerning learning about weather science (outcome) and student characteristics (subject) regarding engagement in statistical norms (rules/norms).

Engaging Student Learning With Models Through the Epistemology of Models

Anupong Praisri*, Kasetsart University (Bangkhen Campus), Thailand
Chatree Faikhamta, Kasetsart University (Bangkhen Campus), Thailand
Akarat Tanakand, Kasetsart University (Bangkhen Campus), Thailand
Samia Khan, The University of British Columbia, Canada

ABSTRACT
Modeling is an important practice for teaching and learning science, and the epistemology of models is crucial in underpinning modeling practices. In this study, we sought to understand how teachers' epistemology of models engages students' learning with models. In particular, we examined three science teachers' epistemology of models in lesson study (LS). Several specific dimensions of the epistemology of models, including the existing nature of models, its purpose, model multiplicity, evaluation of model, and model changeability, served as a theoretical background. Data obtained from interviews and classroom observations were analyzed using cross-case analysis. The results suggest that each teacher's epistemology of models was demonstrated through different teaching paradigms, including positivism and constructivism. The nature and purpose of existing models influenced the other dimensions and were key to student engagement, which was reflected in their work. Our findings also indicate that two teachers in particular sought evidence to support models, multiple models, and interpretive explanations—one sought to converge on existing single-form models. Also discussed is this study's contribution to using the epistemology of models in professional knowledge for teaching modeling practice.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set
Assessing and Enhancing Scientific and Engineering Practices
20-Mar-24, 1:45 PM-3:15 PM
Location: Plaza Court 6

Chunking Code, Representation, and Science Content to Enhance Secondary Students' Participation in Computational Science Investigations

Christopher Lore*, The Concord Consortium, USA
Hee-Sun Lee, The Concord Consortium, USA
Amy Pallant, The Concord Consortium, USA
Jie Chao, The Concord Consortium, USA

ABSTRACT
There is a growing need for curriculum materials that integrate science practices with computational thinking. This research applied the design principle of chunking (Miller, 1956) to the design of computationally supported geo-scientific investigations for high school students and examined students' claims and explanations that answered scientific questions addressed in the investigations. In the design of student investigations, we strategically chunked block coding, visual representations, and science content. We used scientific claim

and explanation prompts embedded in three computationally-mediated scientific investigations around the earthquake cycle. Research questions are (1) what claims students made about a scientific question around earthquake phenomena and (2) how they explained their answer in terms of coding, representation, and science content. The findings indicate that students were able to use code to carry out these investigations and interpret the representational output of a simulation they manipulated using code. However, we identified a need for incorporating further supports so that students could evaluate and reflect on whether their code accurately represents the problem they are trying to solve. We also found that understanding one aspect of the chunked information, for example the representation, is essential to understanding another aspect, such as science content.

Evaluating Singapore Middle School Students' Grasp of Scientific Practices
Yann Shiou Ong*, Nanyang Technological University, Singapore
Yew-Jin Lee, Nanyang Technological University, Singapore
Miechie Leowardy, Nanyang Technological University, Singapore

ABSTRACT

The Singapore science curriculum framework has recently been revised to incorporate the Practices of Science. One component, the Ways of Thinking and Doing in Science (WOTD), closely resembles the US Next Generation Science Standards' scientific and engineering practices. A 12-item survey instrument was developed for evaluating students' grasp of scientific practices and validated in a pilot study with high-ability middle school students (Grades 7-8) (n=82) in a Singapore secondary school. The items mapped onto practices across the three spheres of scientific activity: investigating, explaining, and evaluating. Pilot study findings suggest the difficulty of items in the investigating and explaining spheres matched the students' abilities. However, items in the evaluating sphere were more demanding for the students. The findings likely reflect students' school science experiences where investigation activities and explaining/modeling within the context featured in the survey items are common while argumentation activities are rare. Some items/rubrics were revised following inter-rater reliability checks and Rasch analysis. The revised survey will be implemented with a different group of students and the results will be shared at the NARST conference.

Impacts & Moderation of a Model-Based High School Biology Program on Student Outcomes
Christopher Wilson*, BSCS Science Learning, USA
Cynthia Passmore, University of California Davis, USA
Molly Stuhlsatz, BSCS Science Learning, USA
Cari Herrmann Abell, BSCS Science Learning, USA
Jeffrey Snowden, BSCS Science Learning, USA
Hessan Ghanimi, University of California Davis, USA
Patricia Olson, BSCS Science Learning, USA

ABSTRACT
This study explores the impact of a year-long high school biology program that generates scientific understanding by providing students with opportunities to engage in modeling. The goal of the project is to study the impact of the program and expand the promise of efficacy and feasibility established in previous work. The perspective that scientific models are sense-making tools is a lever point we use to help teachers transform their science instruction and enhance student learning. We explored impacts of the treatment compared to business-as-usual materials with 48 teachers in Northern California. Findings show both groups of students demonstrated increases in their biology content knowledge, but the increase in the treatment group was significantly greater than the comparison business-as-usual group ($p<0.05$, Hedges' g effect size = 0.154). Baseline equivalence was present for the two treatment groups. Of the four moderating variables that were explored, the teacher's Need for Closure was a significant negative moderator on the student achievement outcome, with teachers with a higher tolerance for ambiguity being more effective.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Confronting Biases and Affirming Identities Across Machine Learning, Generative AI, and Undergraduate STEM Research
20-Mar-24, 1:45 PM-3:15 PM
Location: Governor's Square 17

Barriers of Machine Language in African Schools: Testing the Efficacy of Cultural Relevant Pedagogy

Abdulazeez Balogun*, Lagos State University, Nigeria
Olasunkanmi Gbeleyi, Lagos State University-ACEITSE, Nigeria
Onuorah Benjamin, Lagos State University-ACEITSE, Nigeria
Peter Okebukola, Lagos State University-ACEITSE, Nigeria

ABSTRACT
This study investigated Africa's gender sensitivity towards machine language, and the effect of technology and indigenous knowledge on the subject matter. Two null hypotheses were tested on achievement score of students and in the attitude of male and female students taught machine language using CTCA and lecture method. Two groups pre-test- post-test quasi-experimental research design and a descriptive survey research design was used during this research. An Achievement Test in Machine Language (ATML) and a Machine Language Attitude Questionnaire (MLAQ) respectively were used to collect data. The instrument was validated and the reliability were 0.85 and 0.76 respectively. A total of 52 senior high school students offering computer studies participated in the study. Mean and SD were used to analysed the research questions. The ancova was used to analyse quantitative data, while the qualitative data from interview of some randomly selected students. The results showed that, the experimental group significantly outperformed the control group in achievement [$F(1,49)=5.235$; $p<.05$]. Within the scope and limitation of the

study, it is recommended that CTCA should be used tentatively by computer studies teachers in teaching (ML).

The Potential Effects of AI Implicit Bias on Motivational Dispositions

Robert Monahan*, North Carolina State University, USA
Amanda MacCormac, North Carolina State University, USA
James Minogue, North Carolina State University, USA

ABSTRACT

The rapid integration of artificial intelligence (AI) in 21st-century education settings raises serious concerns about its latent biases, especially with the rising adoption of generative AI tools in learning environments. This theoretical work delves into the implications of AI's implicit biases, particularly related to gender and race, on students' motivational dispositions in Science, Technology, Engineering, and Mathematics (STEM) fields, which are already grappling with underrepresentation. Drawing from Expectancy-Value Theory, Self-Determination Theory, and Social Identity Theory, the authors explore the potential adverse effects of biased AI-generated content on student motivation, self-concept, and identity. Recognizing the powerful influence of "othering" and the profound consequences of diminished self-efficacy and confidence, this paper aims to understand the complex interplay between AI bias and students' sense of belonging. By proposing a mixed methods analysis of users' perceptions of AI biases and their associated impacts, this work aims to help unlock strategies to foster an inclusive digital learning landscape and emphasizes the need for educators and AI developers to collaboratively minimize these biases. This exploration underscores the importance of mitigating the adverse effects of AI bias to promote equitable and inclusive educational environments for all students.

A Qualitative Examination of Social and Science Identities Prior to a Post-Baccalaureate Research Program

Tina Zecher*, Northern Arizona University, USA

ABSTRACT

Diverse representation in the STEM workforce continues to be a critical issue in the United States despite decades of effort and millions of dollars to improve a systemic problem. One practice shown to support post-secondary students from historically marginalized communities in STEM pathways is participation in undergraduate research. However, there remain challenges in getting these students to engage in these opportunities and there is little research to understand why. This study examined the social and science identities of four students considered to have multiply marginalized identities in STEM and how internalized societal messages influenced their (non-)participation in undergraduate research. Using a phenomenological approach, the participants' science identities were explored through the lens of interest, recognition, competency, and performance, and data were cross analyzed for emerging patterns of dissonance or agreement between positive or negative contributors to science identity; values, beliefs, and attitudes in relation to social and science identities; and themes of what research is and means. Results from this work may serve as a tool for practitioners looking to understand how marginalized students negotiate

their social and science identities and provides insight into the barriers faced when attempting to have space in the science and research field.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set
Expanding the Justice-Centered Ambitious Science Teaching Epistemic Community
20-Mar-24, 1:45 PM-3:15 PM
Location: Governor's Square 10

Justice-Centered STEM Education to Address Pressing Societal Challenges
Okhee Lee*, New York University, USA

ABSTRACT
Our conceptual framework for justice-centered STEM education incorporates three interrelated principles: (1) justice-centered STEM education engages students in pressing societal challenges that disproportionately affect minoritized groups; (2) given the complexity of pressing societal challenges, justice-centered STEM education leverages the convergence of STEM subjects, including data science and computer science, to explain these challenges; and (3) justice-centered STEM education engages students in designing justice-centered solutions. Our conceptual framework is grounded in an asset-based view of all students, especially multilingual learners (MLs). First, the framework cultivates MLs' transnational experiences and knowledge as assets. Second, the project cultivates MLs' rich repertoire of meaning-making resources as assets. In our collaboration with a middle school science teacher, our prototype instructional unit engaged all students, including MLs, in analyzing COVID-19 data within the US and across countries. Using COVID-19 as an example of a pressing societal challenge, our conceptual framework could be applied to other societal challenges, including climate change and sustainability. Our conceptual framework for justice-centered STEM education could extend the current literature and policy into potential future approaches to justice-centered STEM education with MLs.

Justice-focused Community Agency to Transform Classroom Teaching
Marina Alexio, University of Minnesota, USA
Bhaskar Upadhyay*, University of Minnesota, USA
Kamal Koirala, Tribhuvan University, Nepal

ABSTRACT
This study explores how a community utilizes its political, experiential, cultural, and economic power to influence what gets taught in the community school and how contents are taught in the context of a school with a large number of internal migrant students. Many migrant families in Nepal work and live near factories that produce a large amount of air and water pollutants; thus increasing the risk of respiratory and waterborne health issues. Since the school heavily relies on migrant children for school funding, the migrant community has economic power to influence classroom teaching and learning, specifically science – a

resource intensive subject. We drew from the ideas of governmentality and intersectional climate justice. We thematically analyzed the data and made three assertions. Parents (community members) realized agency through topics on health and sleep deprivation, parents provide experiential and cultural knowledge to include in science activities and discussions (oral and written), and teachers and parents had a sense of "ambivalence" about the high-stakes externally graded exams. A key aspect of this study is that community, if schools encourage, can help drive science teaching that looks and feels more caring to community issues.

Co-Creating With-ness, Vitality, and Axiological Tools for Justice-Oriented Elementary Science Teaching

Andrea Henrie*, Vanderbilt University, USA
Heidi Carlone*, Vanderbilt University, USA
Heather Johnson*, Vanderbilt University, USA
Adam Bell, Vanderbilt University, USA
Tessaly Jen*, Vanderbilt University, USA
Sarah Lee*, Vanderbilt University, USA
Liwei Zhang, Vanderbilt University, USA
Hannah Ziegler, Vanderbilt University, USA

ABSTRACT
For five years, we have worked to co-create an epistemic community of elementary teachers and university researchers committed to ambitious and equitable science teaching. Over time, the work was also about values and emotions, two dimensions of professional learning critical for learning to become justice-oriented educators. We wondered, what ontological, axiological, and affective orientations supported the group's cohesiveness and to the joint project of becoming justice-oriented science educators? We examined video and fieldnote data from summer professional development (PD), video clubs, and teacher interviews to identify themes of shared displays of affect/emotion, values, and structural arrangements that facilitated those moments. Our explanation for why and how our group developed and sustained social cohesiveness over time can be partially explained by axiological tools that were co-developed via a with-ness ontology, and bolstered by vitality shared among the group. For teacher educators, this poster offers tools that support the relational work of cultivating the values and emotions of all participants, including our own, in the learning community.

Weaving Opportunities for Justice-Centered Science Teaching into a Secondary Science Methods Class

DelVechio Rich*, Montclair State University, USA
Delia Furer*, Montclair State University, USA
Douglas Larkin*, Montclair State University, USA

ABSTRACT
This poster details a systematic review of the syllabi and instructional materials for the course "Methods of Teaching Secondary Science" over the past three years that investigates the

various ways in which justice-centered pedagogy has been incorporated into the course. The poster will highlight examples of structures and strategies for the inclusion of justice-centered course content, including epistemic justice (Stroupe, 2023), into the weekly operation of the course.

Preparing Teachers for Rigorous and Equitable Science Instruction in Linguistically Diverse Classrooms

Alexis Rutt*, University of Mary Washington, USA

ABSTRACT

Despite growing linguistic diversity in K-12 schools, emergent bilinguals (EBs) remain underrepresented in advanced STEM courses. This is an important roadblock to justice-oriented and equitable science education: advanced STEM courses prepare students for careers in high-paying STEM fields and prepare all students for active and informed engagement in STEM-related societal discourse.

A possible contributor to EBs' lack of access to rigorous STEM instruction is the minimal preparation teachers receive for teaching STEM in linguistically diverse classrooms. As a result, teachers struggle to teach in a way that is responsive to their EBs, slowing EBs' STEM content development and movement into more rigorous classes. One solution is to prepare teachers for linguistically diverse classrooms within the context of STEM education. We developed and implemented in our science methods courses an instructional framework for preparing teachers to teach student-centered, language-and literacy-integrated science. The framework's five instructional practices leverage EBs' academic, cultural, and linguistic assets as they engage in language-rich science and engineering practices. Results indicate that, following participation in the methods courses, pre-service teachers integrated framework practices in their instructional planning and teaching, and felt more confident teaching EBs, yet areas for growth remain. Detailed results and implications will be discussed.

An Ethical Imperative: "Working Difference" In Science Teacher Education Through a Posthuman Lens

Sophia Jeong*, The Ohio State University, USA
Ashlyn Pierson*, The Ohio State University, USA
Teo Keifert*, University of North Texas, USA
Andrea Henrie*, Vanderbilt University, USA
Heather Johnson*, Vanderbilt University, USA
Bethany Daniel*, Vanderbilt University, USA
Sarah Lee, Vanderbilt University, USA

ABSTRACT

The purpose of this conceptual paper is to re-configure elementary preservice science teachers' becoming as accounts of "working differences" (Ellsworth & Miller, 2014) during an elementary science methods course. By engaging in a process of "working differences", we aim to rupture the hegemonies that arise from the ontology of the same-ness, which takes a strong hold of our thought persistently not only in science education but also in our worlds broadly (Roth, 2008). Our research question asks: How might "working differences" show up when preservice teachers are engaged in fostering multiple and fluid conceptions of equity and imagine a more equitable, inclusive and justice-centered pedagogy?

Justice-Centered Ambitious Teaching: Where Teachers Chose to Start

April Luehmann*, University of Rochester, USA
Yang Zhang, Northwestern University, USA
Hannah Cooke, University of Connecticut, USA
Todd Campbell, University of Connecticut, USA
Déana Scipio, Islandwood, USA
Priya Pugh, Islandwood, USA

ABSTRACT

Justice-centering needs to be prioritized in all aspects of science instruction. That said, the field continues to struggle to operationalize and refine what is meant being transformative aspects of ambitious and equity-centric science teaching. This study investigated where, how and why nine professional learning communities (PLCs), consisting of 55 secondary teachers, focused initial efforts to iteratively design, understand and implement justice-centered ambitious practices. Each PLC conducted multiple cycles of design-based research during the 2021-22 school year and documented their process and results in "Practice Briefs" that served as the primary data for this study. Findings highlight the predominantly transformational ways PLCs operationalized equity, adding texture to and expanding the justice-centered, ambitious framework we brought to the analyses. Expanding the epistemic community that is working to understand and operationalize just and ambitious teaching by including and amplifying the voice of teachers, as in this study, can result in context-rich practices that utlimately refine and expand current notions of equity-centered teaching.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set
Pedagogy Matters: Assessing Equitable Instructional Practices and Impacts
20-Mar-24, 1:45 PM-3:15 PM
Location: Governor's Square 16

Development and Validation of the BOLD Protocol: Measuring Biology Teachers' Culturally and Linguistically Responsive Instruction

Niki Koukoulidis*, University of Florida, USA
Jinnie Shin, University of Florida, USA
Julie Brown, University of Florida, USA
Mark Pacheco, University of Florida, USA

ABSTRACT

This study presents preliminary findings of the development and validation of an observation protocol using confirmatory factor analysis. The protocol was initiated as a tool for culturally and linguistically responsive science instruction and includes six instructional constructs from the BOLD framework that work in conjunction with content benchmarks and science

and engineering practices. The constructs include funds of knowledge, meaningful collaboration, attention to language, use of multiple modalities, affirming students' identities, and promoting sociopolitical consciousness. Analyses in this study were carried out with a sample of 100 secondary biology and marine biology lessons in culturally and linguistically diverse classrooms located in the southeastern US. Results of the preliminary analyses reflect a moderate level of consistency across the items, and individual constructs demonstrate noticeable variances. We conclude that these discrepancies are a result of factors such as multidimensionality, differing factor loadings, or violations of model assumptions. This calls for further investigation to revise or eliminate such items to create a more consistent measure within each factor.

Potency of Culturo-Techno-Contextual Approach in Enhancing Achievement of Senior Secondary School Physics Students in Optics.

John Ogonenwe*, Lagos State University, Nigeria
Tunde Rahman, Lagos State University, Nigeria
Peter Okebukola, Lagos State University, Nigeria
Juma Shabani, universite du Burundi, Burundi
Ibukunolu Ademola, Lagos State University, Nigeria

ABSTRACT

The Culturo-Techno-Contextual Approach (CTCA) is an educational method that combines culture, technology, and context to improve students' understanding of Science, Technology, Engineering, Art, and Mathematics (STEAM) subjects. This approach addresses challenges in comprehending complex concepts, particularly in physics. Physics is a foundational science that plays a crucial role in various scientific disciplines. However, students often struggle with concepts like optics at the secondary school level. To address this, this study investigated the effectiveness of CTCA in enhancing students' physics achievement, specifically in optics.
The research involved 116 students from two senior secondary schools, with 61 males and 55 females. One school received CTCA treatment (experimental group: 36 males and 34 females), while the other used traditional methods (control group: 25 males and 21 females). The study employed mixed methods, combining quantitative and qualitative approaches. Analysis of covariance (ancova) procedure with pre-test scores as covariates was done using IBM-SPSS version 25. The results demonstrated that the experimental group using CTCA outperformed the control group in terms of academic achievement. This finding underscores the significance of CTCA in improving student performance in optics and suggests a statistically significant difference compared to traditional lecture-based teaching, irrespective of students' gender.

Increasing Active Learning Methods Improves Engineering Mathematics Course Outcomes, Especially for Underrepresented Students in STEM

Katherine Golway*, University of Louisville, USA
Campbell Bego, University of Louisville, USA
Shannon Derkson, University of Louisville, USA
Jeffrey Hieb, University of Louisville, USA
Marci DeCaro, University of Louisville, USA

ABSTRACT
Students underrepresented in science, technology, engineering, and mathematics (STEM) fields in terms of race/ethnicity and/or socioeconomic status tend to have lower performance in these courses than their well-represented peers (Ballen et al., 2017). The present study compared student performance in an introductory engineering mathematics course modified from a lecture format to increase active and cooperative learning (lecture, early active, and late active conditions). Students' final grades improved in both active conditions compared to the lecture condition, with slightly greater improvement when collaboration was added (late active). Underrepresented (UR) students' final grades were marginally boosted under the early active learning condition compared to lecture, but significantly improved during the cooperative active learning years. Further, a gap was found between UR and non-UR students' grades in the traditional lecture format. This gap disappeared in both active learning conditions. These findings extend evidence that active learning may be especially beneficial for underrepresented students in engineering mathematics and suggest that cooperative learning may be a necessary component of this benefit. STEM instructors should consider incorporating both active and cooperative learning strategies into their course structure, especially in courses that typically have a grade gap between UR and non-UR students.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set
Technology in Science Teaching and Learning
20-Mar-24, 1:45 PM-3:15 PM
Location: Governor's Square 14

Differences in ICT TPACK Efficacy Among Science Teachers in Elementary and Middle Schools

Adjoa Mensah*, University of Nevada Las Vegas, USA
Mayra Marquez Mendez, University of Nevada Las Vegas, USA
Tina Vo, University of Nevada Las Vegas, USA

ABSTRACT
Research acknowledges disparities in Information and Communication Technology (ICT) efficacy among elementary and middle school teachers, but research focusing on ICT levels among primary education teachers is limited, particularly around their science instruction. This study investigates the relationship between elementary science teachers' instruction and their efficacy in ICT planning, implementation, and science efficacy. Using the ICT TPCK (Angeli & Valanides, 2009) adapted to science, we explored possible relationships between the ICT efficacy of elementary and middle school science teachers along with their science efficacy. Technology, Pedagogy, and Content Knowledge (TPACK) replaced Technological Pedagogical Content Knowledge (TPCK). "TPACK" reflects the concept that constructs are interconnected and should be considered together when implementing educational technology. This quantitative proposal pulls data from a presurvey of 115 teachers' professional development and conducts a pairwise t-test along with a one-way ANOVA to

explore how ICT TPACK and science efficacy are connected. Teachers in this study have a wide range of background experiences (e.g., none to bachelor degrees in sciences) along with time teaching (e.g., first-year teachers to 25+ years). Findings indicate that although elementary and middle school teachers planned ICT TPACK similarly, their implementation and linkages to teacher efficacy scores differed.

Scaffolding Students' Co-Construction and Peer-Critiquing of Carbon Cycling Models and Investigating the Effects

Hsin-Yi Chang*, National Taiwan Normal University, Taiwan

ABSTRACT

The topic of carbon cycling has become increasingly important. For example, a good carbon cycle model provides insights into useful and creative solutions for the global warming issue that society currently faces. The purpose of the study was to develop learning activities and scaffolds that facilitate students' modeling of carbon cycling and to investigate the effects. Specifically, online co-construction and peer-critiquing learning activities with collaboration, content, and representation scaffolds were developed. A total of 51 high school students engaged in the learning activities with the scaffolds. The student-generated models of carbon cycling were collected during the pretests, class sessions, and the posttests. The models were analyzed and rated based on detailed coding rubrics to indicate the students' modeling performances on the topic of carbon cycling. The results indicate that the designed activities and scaffolds were effective in facilitating the students' modeling performances. Moreover, the models generated during group collaboration in class showed the best quality on average, indicating the potential benefits of collaboration and interaction that the co-construction and peer-critiquing activities afford. The study contributes by providing examples and empirical evidence, and by extending perspectives for the use of co-construction and peer-critiquing as instructional approaches and learning strategies.

Leveraging Learning Experience Design to Foster Cognitive and Behavioral Impact with Embedded Video Questions

Joseph Wong*, University of California, Irvine, USA
Lindsey Richland*, University of California, Irvine, USA
Brad Hughes*, University of California, Irvine, USA

ABSTRACT

Amidst the disruptions caused by COVID-19, maintaining learner engagement in traditional and online courses has become a significant concern. This study explores the use of embedded video questions in an undergraduate Biology course grounded in the Learning Experience Design (LXD) pedagogical paradigm with the objective to reduce cognitive load and facilitate cognitive processing in order to promote active learning and knowledge acquisition by operationalizing the testing effect. Results show that embedded video questions significantly improved learners' quiz grades, course participation, page views, and online engagement while reducing mind-wandering and cognitive load. Results also revealed learners' engagement is dependent on their levels of self-regulation, mind-wandering, and cognitive load. The study highlights the potential effectiveness of LX-

designed online courses with embedded video questions, emphasizing intentional design decisions for supporting student knowledge outcomes, reducing cognitive load, and supporting students' learning behaviors. Furthermore, this study documents our design efforts for how other courses can adopt the LXD paradigm with embedded video questions to help support undergraduate learning experiences with evidenced-based pedagogical "edtech tools" at scale.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set
NOS in Pre-Service Teacher Education
20-Mar-24, 1:45 PM-3:15 PM
Location: Plaza Court 3

Improving Preservice Elementary Teachers' Conceptions of Nature of Science Through Participation in Citizen Science Projects

Mila Rosa Carden*, University of North Texas, USA
Karthigeyan Subramaniam*, University of North Texas, USA
Christopher Long*, University of North Texas, USA
Nazia Khan*, University of North Texas, USA

ABSTRACT
Very little research examines the intersection between citizen science (CS) and the nature of science (NOS). This investigation addresses this gap in the research base by focusing on using CS as a context to improve 25 preservice elementary teachers' conceptions of the nature of science (NOS) within a science methods course. The participants are 15 White Americans (1 male, 14 females), 8 Hispanic women and two Black women. Quantitative and qualitative pre-course and post-course students' Understanding of science and scientific enquiry (SUSSI) response and course reflection analysis indicated that participants' NOS conceptions improved and were consistent with contemporary science education reforms, post-course, particularly on the use of diverse scientific methods and creative NOS aspects. This strong growth in these NOS aspects was reflected in their identification of the impact of their participation in CS on their NOS conceptions; participants identified impact on use of diverse scientific methods most frequently among NOS aspects. These findings offer initial evidence of the potential of CS as a learning context to enhance the conceptions of NOS of learners and promote the potential of CS for humanistic science learning, where participants participate in projects that are personally relevant and meaningful to their lives

Exploring Three Secondary Preservice Teachers' Views of NOS, Beliefs about Teaching NOS, and NOS Teaching

Kelsey Beeghly*, University of Central Florida, USA
Su Gao, University of Central Florida, USA
Jerrid Kruse, Drake University, USA

ABSTRACT
This multiple-case study investigated the changes in three secondary science preservice teachers' views of the nature of science (NOS), their beliefs about the importance of NOS, as well as how these changes relate to their NOS teaching at the end of a science methods course guided by the reconceptualized family resemblance approach (RFN). Data sources included pre and post course individual interviews, as well as each preservice teachers' lesson plan and teaching video from the end of the semester. Findings showed that there was an overall improvement in preservice teachers' views of NOS related to each RFN category. One preservice teacher continued to hold misconceptions about scientific theories and laws after the course. Two preservice teachers developed far-reaching beliefs in the importance of teaching NOS that transcend the classroom and were able to implement explicit-reflective NOS instruction at the end of the course. Despite having accurate views and knowledge of effective NOS teaching and professing a belief in the importance of teaching NOS, the third preservice teacher did not enact explicit-reflective NOS instruction at the end of the course. Contributions to the NOS literature were identified and implications for research and science teacher education were discussed.

Investigating Nature of Science Conceptions and Argumentation Components in a Science Methods Course
Rola Khishfe*, American University of Beirut, Lebanon

ABSTRACT
The study examined (a) the development in preservice teachers' conceptions of NOS, and (b) the development in preservice teachers' argumentation components as a result of an explicit approach that targets NOS and argumentation. Twenty students, who were preservice teachers at the elementary level, participated in the study where they were enrolled in a science methods course that emphasized explicit instruction of NOS and argumentation through different hands-on activities (addressing scientific and socioscientific contexts). Data sources were questionnaires (addressing scientific and socioscientific contexts) followed by semi-structured interviews that were administered in a pre-/post fashion. Results indicated an overall improvement of the participants' NOS conceptions and argumentation components in the scientific context and the socioscientific context, with slightly more improvement in the scientific context. The results are interpreted considering the following issues: explicit approach for NOS and argumentation, connected approach to teach NOS and argumentation, and scientific vs. socioscientific contexts. Implications related to the teaching of NOS and argumentation are discussed.

Exploring Elementary Preservice Teachers' Scientific Explanations: A Comparative Analysis using NOSE Framework and CER Model
Sahar Alameh*, University of Kentucky, USA
Blake Sampson, University of Kentucky, USA

ABSTRACT
This study investigates the construction of scientific explanations by elementary preservice teachers (PSTs) using the Nature of Scientific Explanations (NOSE) Framework and the

Claim-Evidence-Reasoning (CER) model. While contemporary science education stresses the significance of scientific explanations, a clear and universally agreed-upon definition remains elusive. Guided by research questions, the study examines how PSTs' explanations of a phenomenon fare under both frameworks.
Findings indicate that the NOSE Framework offers a comprehensive analysis, encompassing various structural elements and explanation types. In contrast, the CER model focuses primarily on claim, evidence, and reasoning components, often missing the intricacies of complete explanations. The study reveals challenges faced by PSTs in constructing thorough and apt scientific explanations.
This research underscores the necessity of context-specific frameworks for analyzing scientific explanations in educational contexts. Implications encompass the adaptation of the NOSE framework for pedagogical purposes, deeper insight into PSTs' explanation abilities, and validation of the NOSE framework as a robust assessment tool. The study contributes to enhancing science education practices, emphasizing the complexity of scientific explanations and advocating for dedicated frameworks to effectively evaluate and scaffold this crucial skill.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set
Building Teachers' Capacity on Climate Literacy
20-Mar-24, 1:45 PM-3:15 PM
Location: Plaza Court 8

Developing Elementary Teachers' Self-efficacy for Climate Change Teaching and Climate Change Literacy Using Learning Technologies
Lauren Wagner*, Florida State University, USA
Amal Ibourk*, Florida State University, USA
Khadija Zogheib*, Florida State University, USA

ABSTRACT

Elementary teachers need support through professional development to increase their self-efficacy for climate change teaching as well as their climate change literacy. This study examines how NGSS-aligned climate change learning activities that incorporate learning technologies support teachers' climate change literacy and self-efficacy, or beliefs and attitudes about teaching climate change science, for in-service elementary teachers. In this study, we outline how the learning technologies, specifically, data visualizations and climate models, enhanced the teachers' climate change literacy and self-efficacy. Overall, the learning technologies helped the teachers make connections between how specific human activities can increase the number of greenhouse gases in the atmosphere, and thus increase global temperatures over time. Furthermore, the experience also supported the teachers in developing personal connections to the effects of climate change and imagining possible futures.

Watershed Moments: Investigating Teacher Motivation and Benefits to Place-Based Environmental Professional Development Workshops

Jessica Stephenson Reaves*, Kennesaw State University, USA
Rasheda Likely, Kennesaw State University, USA
Anna Maria Arias, Kennesaw State University, USA

ABSTRACT

Teachers have often not had opportunities to engage in equitable place-based environmental learning themselves, or opportunities to develop the confidence, knowledge, and practice for supporting students in considering local-global environmental issues. To support the design of these place-based professional development opportunities, we investigated teachers' motivation and their realized benefits of engaging in a place-based professional development workshop focused on inquiry into the local-global problem of water quality developed in collaboration with a local university and an aquarium. We conducted a qualitative case study of fourteen in-service teachers involved in the professional development workshop. Data sources included participant interviews, pre-workshop surveys, participant observer notes, and participant artifacts. Teacher motivations included personal learning for themselves and their students, learning from/with others, and making connections for students. Realized benefits included developing a community of practice, and a re-commitment to learning for themselves and for teaching their students. These analyses have implications for creating meaningful learning opportunities for teacher learning, creation of communities of practices, and the study of local-global issues like water quality.

Building Capacity to Teach and Learn Earth & Environmental Data Science at Smaller Minority Serving Institutions

Nathan Quarderer*, CU Boulder/CIRES/ESIIL/Earth Lab, USA
Emily Ward, CU Boulder/CIRES/ESIIL, USA
Katherine Halama, CU Boulder/CIRES/ESIIL/Earth Lab, USA
Jennifer Balch, CU Boulder/CIRES/ESIIL/Earth Lab, USA
Elsa Culler, CU Boulder/CIRES/ESIIL/Earth Lab, USA
Chelsea Nagy, CU Boulder/CIRES/ESIIL/Earth Lab, USA
James Sanovia, CU Boulder/CIRES/ESIIL/AIHEC, USA
James Rattling Leaf, CU Boulder/CIRES/ESIIL/NC CASC, USA
Anne Gold, CU Boulder/CIRES/ESIIL, USA

ABSTRACT

We live in a rapidly changing environment. We also live in a time of rapid earth and environmental data production and synthesis, courtesy of an ever-growing network of remote sensing and in-situ monitoring infrastructure capable of generating terabytes of data every day. This creates a need within the earth and environmental sciences for researchers who possess skills in data analytics, capable of working with large data and reporting findings in a way that will be helpful for decision makers and the public. One approach to help begin to meet this need are NSF-supported efforts like the HDR Earth Data Science Corps and ESIIL Stars internship programs, designed to build capacity to teach and learn

Earth and Environmental Data Science (EDS) at smaller Minority Serving Institutions (MSIs) including Tribal Colleges and Universities (TCUs) and Hispanic Serving Institutions (HSIs). The study described here will outline the frameworks of these two EDS programs, and share findings from surveys collected from EDSC and ESIIL Stars participants intended to measure growth across different EDS dimensions. Survey responses were analyzed using Rasch measurement. Participants' responses about EDS career pathways were also analyzed using open-coding. Implications for teaching EDS within historically marginalized communities will be discussed.

Plenary Session
Closing Session
20-Mar-24, 3:30 PM-4:30 PM
Location: Plaza Ballroom ABC/DEF

Committee Meeting
NARST Board of Directors Meeting
20-Mar-24, 5:00 PM-10:00 PM
Location: Directors Row E

Author Index

Aberle, Timothy, 298
Abouelkheir, Mahmoud, 66
Abrams, Binyomin, 427
Abreu, Evan, 165
Adachi, Akira, 14
Adah Miller, Emily, 213, 259, 335, 494
Adams, Betty, 232
Adams, Jennifer, 66, 253, 385
Adams, Matthew, 432, 524
Adekoya, Atinuke, 509
Ademola, Ibukunolu, 282, 537
Adeniranye, Daniel, 127
Adesunloye, Taiwo, 427
Adler, Isabell, 164
Afari, Ernest, 18
Affolter, Renee, 147
Agbanimu, Deborah, 28, 47, 101, 238, 282, 449
Agholor, Rose, 201, 238
Aguiar, Derek, 214
Aguirre-Munoz, Zenaida, 250
Agustian, Hendra, 415
Aguwa, Aguwa, 391
Ahanonye, Agnes, 511
Ahmed, Khadija, 77, 179
Ahmed, Sameh, 381
Ahn, Junhwan, 7
Ahn, Wanjoo, 169, 377
Aikens, Melissa, 235
Aini, Rahmi, 126, 202
Akcayir, Gokce, 135
Akcil Okan, Ozlem, 178
Akdemir, Zeynep, 217
Akerson, Valarie, 112, 157, 257, 415
Akgun, Selin, 104
Akinpelu, Joshua, 509
Akinyemi, Olutosin Solomon, 238
Aksoy, Sule, 128, 358
Aksoz, Busra, 73
Aksöz, Büşra, 73
Al Balushi, Sulaiman, 381
Alahmad, Nidhal, 267
Alam, Irfanul, 451
Alameh, Sahar, 541
Alamri, Hamdan, 267
Al-Amri, Mohammed, 381
Alatawna, Nabeh, 230
Albogami, Maha, 267
Alboher Agmon, Vered, 21
Alexio, Marina, 533
Alfayez, Abdulaziz, 268
Alhabsi, Nabil, 381
Alhinai, Marwa, 381
Alhosni, Khoula, 381
Ali Bhatti, Haider, 128
Allchin, Douglas, 181
Allen, Annie, 147, 149
Allen, Julie, 99
Allen, Winter, 372
Almasabi, Zahrah, 267
Almufti, Abdo, 267
Almusharraf, Norah, 254
Alshamrani, Saeed, 267
Alshaya, Fahad, 268
Alston, Ann, 116
Altindis, Nigar, 235
Altunbas, Havva Gorkem, 510
Alvarado, Carolina, 233, 374
Al-Yahmedi, Amur, 381
Alzen, Jessica, 1, 134, 437
Amer, Mahmoud, 381
Amin, Syahrul, 377
Ammentorp, Louise, 287
Anderman, Eric, 264
Anderman, Lynley, 264
Andersen, Sage, 186, 220, 438
Anderson, Charles, 311
Anderson, David, 308
Anderson, Eleanor, 213
Anderson, Emma, 103
Anderson, Ingrid, 23
Anderson, Janice, 89
Anderson, Shanna, 298
Andersson, Justin, 452, 456

Andreozzi, Haley, 424
Andrew-Ihrke, Dora, 34
Andrews, Lin, 288
Annetta, Len, 447
Antink-Meyer, Allison, 191
Antonenko, Pasha, 330
Antonenko, Pavlo, 284, 374
Anwar, Tasneem, 16
Apata, Olukayode, 483
Apedoe, Xornam, 245
Arada, Kathleen, 341
Arango-Caro, Sandra, 331
Archer, Louise, 172, 329, 445, 524
Arellano Haberberger, Michelle, 331
Arhonditsis, George, 405
Arias, Anna, 239, 343, 543
Ariyaratne, Tulana, 415
Arriagada Jofre, Victoria, 22
Arslan, Harika, 27
Arvatz, Avivit, 266
Asim, Sumreen, 91
Askinas, Karen, 175
Astapova, Anastasiya, 476
Ataide Pinheiro, Weverton, 301
Attipetty, Dhanya, 30
Atwater, Mary, 151
Avarzamani, Farnaz, 15, 512
Avery, Patricia, 121
Aviran, Ehud, 448
Avraamidou, Lucy, 81, 329, 413
Awal, Sheikh Tahmina, 442
Awsaf, Amdad Ahmed, 328
Ayala Chavez, Regina, 286
Ayano, Elizabeth, 177, 179, 520
Aydeniz, Mehmet, 39
Aydin-Gunbatar, Sevgi, 59, 191
Ayers, Kate, 208, 312, 313, 402
Aykut, Coskun, 18
Babichenko, Miriam, 243
Baddour, Rana, 31
Badio, Koree, 358
Badmus, Olalekan, 205
Bahrami, Samira, 25
Bai, Xin, 334
Bai, Yue, 58, 214
Baierl, Tessa-Marie, 449
Bailey, Elizabeth, 239
Bailey, Janelle, 88, 214, 316
Bailey, Jessica, 470
Baker, Samantha, 14
Balch, Jennifer, 543
Baldwin, Brian, 76
Balgopal, Meena, 387, 493, 494
Ball, Doug, 94
Ballard, Heidi, 319, 424
Balogun, Abdulazeez, 509, 531
Bang, Megan, 342, 390
Banilower, Eric, 323
Bano, Roshni, 128
Bao, Hanhui, 216
Baptista, Monica, 130
Baptiste, H. Prentice, 409
Barak, Miriam, 191, 505
Baram-Tsabari, Ayelet, 3, 20, 362
Baranwal, Divya, 283, 412
Barbieri, Brandon, 76
Barendsen, Erik, 498
Barham, Andrew, 245
Barnes, M. Elizabeth, 126, 202, 203
Barnett, Mike, 346
Barnhart, Tara, 320
Bartels, Selina, 112, 257
Basaraba, Kristian, 135
Baser-Kanbak, Ceren, 18
Bateman, Jennifer, 44, 177, 379, 380, 452
Batres, Brezhnev, 156
Batta, Elliot, 69
Baur, Armin, 255
Bautista, Jessica, 248
Bayer, Irene, 384
Bayram, Dury, 260, 434, 498
Baze, Christina, 237
Bean, Jessica, 183
Beaver, Breanna, 12, 107
Beeghly, Kelsey, 540
Begay, David, 55
Bego, Campbell, 537
Behrendt, Mei Grace, 317

Beigman Klebanov, Beata, 283
Bell, Adam, 534
Bell, Philip, 160, 342
Belson, Sarah, 300
Ben Eliyahu, Einat, 278
Ben Simon, Haya, 105
Bencze, J. Lawrence, 8, 16
Benedict-Chambers, Amanda, 319
Benedis-Grab, Gregory, 111
Ben-Eliyahu, Einat, 278
Benjamin, Onuorah, 531
Bennett, Dorothy, 470
Bennett, Matthew, 176, 208
Bennett, Robert, 36
Bennion, Adam, 174
Bentley, Lillian, 223, 272
Benzoni, Rachel, 273, 379
Berg, Craig, 417
Bergqvist, Mikkel, 325
Berhane, Bruk, 127
Berkowitz, Alan, 182, 183, 184
Bernhard, Tess, 103
Bernier, Jeremy, 24
Bernstein, Debra, 353
Bewersdorff, Arne, 255
Bex, Richard, 330
Bezeljak Cerv, Petra, 193
Bhaduri, Srinjita, 111, 211
Bhagatwala, Tanya, 87
Bhattacharya, Sambit, 373
Bianchini, Julie, 34, 208
Biddy, Quentin, 111, 211
Bilardello, Cameron, 12
Billington, Barbara, 297
Billman, Alison, 383
Bills, Patricia, 207
Bin Syed, Shifath, 195
Binder, Martin, 201
Bintz, Jody, 79
Bismack, Amber, 207
Biswas, Ashis, 337
Black, Sydney, 235
Blair, Kristen, 489
Blakc, Sydney, 235
Blake, Charlie, 72, 349
Blanchard, Margaret, 52, 408, 452, 464
Blanco, Summer, 328
Blank, Matthew, 526
Blauza, Simon, 491
Bleckmann, Tom, 412, 414
Blonder, Ron, 43, 96, 292, 429, 448
Blondonville-Ford, Damaries, 380
Blowers, Paul, 321
Bocko, Paul, 227
Boda, Phillip, 249, 290
Bogner, Franz, 449
Bolden, Edward, 12
Bolte, Claus, 140
Bonham, Scott, 285
Borda, Emily, 404
Bordewieck, Kathleen, 106, 131, 400
Borgerding, Lisa, 12, 107, 164, 180, 405, 519
Bothor, Janne-Marie, 408, 512
Boudreau, Andrew, 374
BouJaoude, Saouma, 31
Bouwma-Gearhart, Jana, 126
Bowen, G. Michael, 41, 309
Bowers, Jonathan, 46, 51, 128, 216
Bowman, Frank, 511
Boyd, Bonnie, 122
Boyd, Kathryn, 55, 56, 57
Boyd, Norris, 178
Boz, Tugba, 49
Braaten, Melissa, 61, 185
Bracey, Georgia, 72, 349
Bradford, Allison, 15
Brand, Brenda, 478
Brandl, Rayelynn, 299
Bredder, Eric, 31
Brennan, Linsey, 386
Bressler, Denise, 195
Bridgeford, Kristin, 523
Brien, Sinead, 524
Brinthaupt, Tom, 53
Brockmann-Behnsen, Dirk, 414
Brockmüller, Steffen, 124
Brodsky, Lauren, 384
Brown, Bryan, 388

Brown, Julie, 279, 356, 371, 409, 536
Brown, Leslie, 120
Brown, Michelle, 209
Brown, Taryrn, 358
Brownell, Cassie, 515
Brownell, Sara, 202
Browning, Lauren, 182, 183
Bruce, Anna, 131
Brunet, Alexandre, 198
Brunner, Jeanne, 85
Buchanan, Duncan, 135
Buchanan, Erin, 440
Buck Bracey, Zoe, 299, 490
Buck, Gayle, 339, 410, 474, 508
Bucknor, Carmen, 446
Buell, Jason, 1, 134, 168, 437, 467
Buessing, Alexander, 108
Buffington, Pam, 528
Bullard, Samuel, 480
Bulleri, Robin, 135, 267
Bunyamin, Muhammad Abd Hadi, 4
Burgess, Terrance, 117, 163, 199
Burgin, Stephen, 503
Burns, Henriette, 128
Burrell, Shondricka, 491
Busch, K.C., 261, 286
Bush, Jeffrey, 111, 211
Bushong, Leslie, 431
Büssing, Alexander, 20
Butler, Tiffany, 66, 353
Butterfield, Sylvia, 446
Buxner, Sanlyn, 237
Buxton, Cory, 153, 304, 468
Byrd, Christyn, 446
Byrd, Scott, 465
Cabe Trundle, Kathy, 76
Cain, Ryan, 406
Cakiroglu, Jale, 59
Calabrese Barton, Angela, 99, 108, 110, 172, 189
Call, Alexandria, 59
Callis-Duehl, Kristine, 331
Cameron, Tajma, 219
Campbell, Todd, 58, 161, 214, 392, 536
Campbell, Vandeen, 251
Campo-Paz, Rocio, 332
Cang, Xuesong, 14
Canipe, Martha, 59
Caplow, Susan, 489
Capobianco, Brenda, 297
Capps, Daniel, 177, 200
Cardella, Monica, 80, 97, 444
Carden, Mila Rosa, 486, 512, 540
Carleton, Karen, 316
Carletta, Liz, 179
Carlone, Heidi, 390, 496, 534
Carlson, Janet, 321
Carpenter, Ethan, 173
Carrier, Sarah, 425, 516
Carrion, Carmen, 332
Carroll, Grace, 96, 144, 396, 525
Carsten Conner, Laura, 416
Carter, Jane, 116
Cartes, Carolina, 97
Caspari, Ira, 425, 426, 521
Caspari-Gnann, Ira, 425, 426, 521
Casper, Aramati, 69, 280, 485
Cassells, Rochelle, 497
Cassidy, Michael, 353
Cassone McGowan, Veronica, 336, 390
Castillo Hernández, Francisco, 265
Castro, Sheila, 356, 409
Castro-Faix, Moraima, 310
Cate, Leandra, 481
Caushi, Klaudja, 427
Cavas, Bulent, 187
Ceren, Melissa, 150
Çetin, Pınar, 256
Ceyhan, Gaye, 10, 502
Chadwick, Cary, 392
Chaffe, Rachel, 66
Chakraverty, Devasmita, 5, 6
Chalfant, Jeffrey, 318
Chalfant, Laura, 96, 144, 396, 403
Champion, Dionne, 156
Chan, Kennedy, 95, 173
Chandler, Hunter, 367
Chang, Hsin-Yi, 539

Chang, Sandy, 469
Chang-Rundgren, Shu-Nu, 362
Chao, Jie, 529
Chapman, Angela, 121, 196
Chappell, Mindy, 156
Chase, Stefani, 58
Chastain, Raymond, 317
Chatham, Elizabeth, 527
Chatzara, Eirini, 404
Chen, Chen, 293
Chen, I-Chien, 473
Chen, Jessica, 433
Chen, Jiaxin, 293
Chen, Jingyi, 390
Chen, Karen, 359, 360, 361
Chen, Pai-rou, 119, 399
Chen, Shih-Yeh, 83
Chen, Ying-Chih, 15, 340, 341
Cheng, Diana, 380
Cherbow, Kevin, 147, 149, 175
Cheung, Kason Ka Ching, 257
Chicas-Mosier, Ana, 223
Childers, Gina, 268, 271, 400
Childs, Joshua, 477
Chin, Chi-Chin, 507
Chin, Doris, 487, 489
Chinn, Pauline, 35, 339, 493, 511
Chiu, Jennifer, 31
Chiu, Mei-Hung, 473
Choi, Kahyun, 104
Chontong, Tony, 493, 494
Chowdhury, Tapashi Binte Mahmud, 187
Christensen, Amy, 356
Christensen, Julie, 240
Christian, Natalie, 317
Chuang, Ya-Ting, 395
Cian, Heidi, 98, 152, 328
Cioffi, Christopher, 188
Cisneros, Laura, 392
Cisterna, Dante, 364, 416
Clark, Carrie, 317
Clark, Ted, 189, 282
Classen, John, 400
Cleary, Timothy, 281
Clough, Michael, 41, 363, 513
Clyde, Malin, 424
Cobern, William, 133, 232
Cobian, Erik, 186
Cobian-Mejia, Erik, 186
Coburn, Mary Kate, 394
Cofre, Hernan, 97, 105
Cohen, Joshua, 444
Cohen, Scott, 163, 396
Coker, Ryan, 274
Colandene, Michele, 353
Colaninno, Carol, 72, 349
Cole, Merryn, 399
Coleman King, Chonika, 356
Coleman-King, Chonika, 356, 358
Collier, Karen, 408
Colston, Nicole, 326
Conley, Zachary, 390, 496
Conlin, Luke, 103
Contino, Julie, 241
Contreras, Isabella, 523
Conville, Kyra, 394
Cook Whitt, Kate, 145
Cooke, Hannah, 335, 536
Cooper, Sara, 63, 148, 149
Corin, Elysa, 465
Cormas, Peter, 125
Corricelli, Jacqueline, 215
Corwin, Lisa, 171, 451, 472
Couch, Brian, 235
Couch, Brock, 195, 235
Courtade, Ginevra, 303
Couso, Digna, 45, 51, 81, 265
Covitt, Beth, 182, 183
Cox, Derek, 91, 92
Cox, Eugene, 42
Crabtree, Lenora, 35, 511
Craven, Laura, 131
Crawford, Felicity, 347
Crespo, Diana, 153, 465
Crespo-Camacho, Diana, 153, 465
Cress, Ulrike, 82
Crippen, Kent, 102, 138, 289, 337, 401, 409, 411

Crissman, Sally, 262
Cromley, Jennifer, 40
Crooks, Celine, 118
Cross Francis, Dionne, 93, 252, 301, 446
Crotty, Elizabeth, 497
Cuchiara, Maude, 400
Culler, Elsa, 543
Cullicott, Cathy, 456
Currey, Barbara, 164
Curtis, Mary, 477
Cyrenne, De-Laine, 136
Czerniak, Charlene, 246
Czinczel, Berrit, 82
Dabholkar, Sugat, 154, 341
Dabran- Zivan, Shakked, 20
Daehler, Kirsten, 119, 270, 399
Dagher, Zoubeida, 113, 466
Dahl, Tarah, 271
Dahlstrom-Hakki, Ibrahim, 470
Dake, Felisha, 304, 468
Dalley, Simon, 237
Dalyot, Keren, 307, 480
Damelin, Daniel, 6
Damjanovic, Victoria, 23
Dang, Nicholas, 217
Daniel, Bethany, 376, 535
Daniel, Kristy, 523
Darche, Svetlana, 270
Dare, Emily, 309, 382
Darienzo, Michele, 351, 429
Dasgupta, Chandan, 495
Dash, Meredeth, 159
Date, Geetanjali, 154
Dauer, Jenny, 368, 451
Dauer, Joseph, 235, 317
Davidesco, Ido, 394
Davidson, Shannon, 2, 298
Davis, Elizabeth, 198, 247, 248
Dawson, Kara, 330
de Albuquerque Trigo, Maiza, 5
De Andrade, Vanessa, 130
De Jesús, Daniel, 75, 363
De La Cruz, Iliana, 290
de los Santos, Elizabeth, 65
de Putter, Lesley, 230
Dean, Steph, 227
DeCaro, Marci, 317, 537
Deig, Amber, 371
Del Core, Corynn, 119
Del Gobbo, Dave, 8, 16
Delen, Ibrahim, 64, 229
DeLeon, Joe, 196
Delgado, Cesar, 359, 360, 361
DeLisi, Jacqueline, 52, 470
Delmore, Kira, 75
Deluca, Joseph, 60, 176, 177, 494
DeLyser, Leigh, 37
Demarse, Maggie, 122
Demir, Kadir, 246
Deniz, Hasan, 157, 191
DeRegis, Isabella, 7
Derios, Ursula, 298
Derkson, Shannon, 537
Desai, Aman, 489
Deshmukh, Narendra, 114, 487
Desi, 234
Deverel-Rico, Clarissa, 307
Dexheimer, Andreia, 72, 349
Di Fuccia, David-Samuel, 408, 512
Diaz, Brayan, 501
Diaz-Silveira, Genelle, 185
Dickerson, Darryl, 127
Dickler, Rachel, 350
Dickson, David, 392
DiDomenico, Jeanne, 385
Dietz, Dennis, 140
Ding, Cheng, 334
Ding, Lin, 26, 376, 486
Doan, Sy, 125
Dodge, Lily, 30
Dolphin, Glenn, 195
Donatelli, Christi, 235
Donovan, Brian, 150, 192, 269
Dorfman, Bat-Shahar, 331
Dori, Yehudit, 13, 266
dos Santos Barbosa da Silva, Matheus, 356
Dou, Remy, 98, 152, 327, 328
Douglass, Annie, 98

Dozier, Sara, 355
Drachsler, Hendrik, 82, 254
Drageset, Darby, 137, 401
Draney, Karen, 182, 183
Dreyfus, Ben, 353
Duckett, Ryan, 246
Duffey, Amanda, 278
Duke, Jessica, 500
Duncan, Ravit, 310, 341
Durak, Benzegül, 10
Dursun, Jale, 517
Durukan, Alper, 59
Duschl, Richard, 310, 412
Dutta, Deborah, 154, 341
Duwe, Samantha, 78
Dyess, Maizie, 188, 386
Eddy, Sarah, 69, 485
Edmonds, Juliet, 116
Edmondson, Elizabeth, 242
Edouard, Kareem, 461
Edri, Ruth, 13
Edwards, Baylee, 202
Edwards, Frances, 21
Edwards, Kelsey, 1, 134, 168, 437
Eichler, Jack, 431
Eidin, Emil, 51, 128, 384
Ejike, Justice, 372
El Halwany, Sarah, 8
EL-Deghaidy, Heba, 267
Elfring, Lisa, 321
Elliot-Famularo, Heather, 392
Elliott, Mary, 303
Elliott, McKenna, 317
Ellis, Joshua, 127, 382
Elmore, Bartow, 44
Elsayed, Rasha, 119, 270, 399
Elsner, Jamie, 77, 129, 277
Emenaha, Uchenna, 357, 479
Emery, Nancy, 472
Emmanuel, Moses, 509
Enderle, Patrick, 178, 244
Engblom, Samuel, 528
Engelschalt, Paul, 129
Ennes, Megan, 90, 364
Ercan-Dursun, Jale, 143
Erdoğan, Niyazi, 483
Erduran, Sibel, 86, 191, 257, 505
Erenler, Sümeyye, 256
Eslami, Maryam, 118
Esparza, Allison, 226, 483
Estrada-Rosado, Eduardo, 359
Ettenauer, Barbara, 153
Evans, Robert, 64
Everson, Howard, 440
Fackler, Ayça, 213, 462
Fagan, Emily, 528
Fagundes, Barbara, 284
Faikhamta, Chatree, 466, 529
Falkenberg, Charlotte, 430
Fan, Nannan, 83, 307, 480
Fang, Yuanyuan, 241
Fang, Zhenhan, 263
Fankhauser, Sarah, 87, 115, 223
Fantacone, Dominick, 163, 242
Farris, Amy, 349
Fayad, Christelle, 221
Fazio, Xavier, 161, 209
Fechner, Sabine, 190
Feinstein, Noah, 163
Feldman, Kimberly, 221
Feng, Shuo, 28
Ferdous, Tanzimul, 106, 526
Fiedler, Daniela, 82, 164, 165
Figueroa, Francheska, 24
Fine, Caitlin, 185
Finger, Lena, 504
Fiorella, Logan, 234
Firestone, Jonah, 413
Fischer, David, 183
Fischer, Matthias, 189
Fischler-Barraza, Maraliz, 515
Fisher, Kelly, 150
Fisher, Matthew, 228
Fitzgerald, Brian, 528
Fitzmaurice, Helen, 259
Fitzpatrick, Chris, 219
Flanagan, Constance, 326
Flanagan, Jean, 79

Fletcher, Trina, 444
Fogelman, Sarah, 211, 277
Forsler, Annika, 499
Forte, Ellen, 439
Fortus, David, 129, 132, 198, 215, 307, 310, 480
Fosbinder, Jennifer, 303
Fowler, Kelsie, 160
Francis, Jahneal, 66
Franco, Luiz, 265
Frausto Aceves, Alejandra, 34, 341
Fredrick, Racheal, 397
Freeman, Alyssa, 53, 456
Freidenfelds, Nicole, 392
Freire, Sofia, 130
French, Elizabeth, 259, 335
Frentz, Thierry, 5
Friege, Gunnar, 266, 397, 412, 413, 414, 417
Froburg, Erik, 424
Frye, Lisa, 249
Fu, Megan, 245
Fuchs, Travis, 19
Fuller, Christina, 469
Fulmer, Gavin, 143, 278, 369, 383, 517
Furer, Delia, 534
Furtak, Erin, 78
Fuselier, Linda, 317
Gabrysch, Brian, 9
Gaete-Cornejo, Jocelyn, 22
Gagnier, Kristin, 150
Gailey, Sara, 406
Galani, Apostolia, 333, 404
Galisky, John, 208, 275
Gallard, Alejandro, 196
Gallo-Fox, Jennifer, 228
Gane, Brian, 385
Ganesan, Uma, 196
Gannon, Paul, 49, 511
Gans, Nancy, 462
Gao, Su, 540
Garbesi, Karina, 158
Garcia Araiza, Marlene, 11
Garcia, Leiny, 470
Garcia, Liliana, 196
Garcia-Baza, Isai, 77
Gardner, April, 149
Gardner, Grant, 35, 53
Gares, Sheryl, 123
Garner, Amanda, 216
Garner, Kevin, 182, 183
Garrity, Deborah, 281
Gasca, Santiago, 353
Gauzy, Selcen, 296
Gbeleyi, Olasunkanmi, 282, 531
Gegear, Robert, 137
Gehrtz, Jessica, 479
Gendreau Chakarov, Alexandra, 111
Genek, Selvet Ece, 486
Gengarelly, Lara, 424
Gengler, Diane, 14
Genz, Joseph, 155
George, Frikkie, 340
Georgiou, Martha, 333
Gerard, Libby, 15
Gerde, Hope, 86
Gericke, Niklas, 108, 192
Gertz, Emilie, 153
Gettings, Bethany, 317
Ghanimi, Hessan, 530
Ghazal, Ihsan, 45, 369
Giamellaro, MIchael, 305
Gibson, Cynthia, 521
Gilbert, Andrew, 227
Gill, Asghar Pervaiz, 232, 368
Gillaspie, Claire, 523
Gilmore, Sarah, 394
Ginzburg, Tamar, 505
Gioti, Katerina, 495
Gisewhite, Rachel, 258
Gist, Jenna, 297
Glandorf, Christian, 409, 427
Glassman, Michael, 264
Glenn, Megan, 424
Glidewell, Loraine, 61, 148, 149
Gliese, Sara, 316
Gnesdilow, Dana, 14
Goforth, Chris, 516
Goforth, Christine, 516

Gold, Anne, 55, 56, 57, 543
Goldstein, Shani, 13
Golshani, Samira, 15, 512
Golway, Katherine, 537
Gombert, Sebastian, 254
Gomez Zaccarelli, Florencia, 22
Gonczi, Amanda, 60
González-Howard, María, 186, 220, 438
Goodey Pellois, Joanna, 41
Goodhue, Tara, 120
Google, Angela, 203
Gordon, Rachael, 468
Gorlenko, Katerina, 173
Gott, Mae Rose, 347
Gotwals, Amelia, 338, 366, 419, 518
Governor, Donna, 88
Grace, Jill, 490
Graham, Savannah, 45, 205, 456
Gransbury, Isabella, 37
Grapin, Scott, 146, 323
Gravel, Brian, 219
Gray, Abbey, 347
Gray, Ron, 58
Green, Andrew, 127
Greenfield, Ben, 349
Greenfield, Benjamin, 72
Greenwell, Zephaniah, 503
Greenwood, Joleen, 249
Greer, Kania, 271
Greussing, Esther, 3
Grieger, Krystal, 271
Griesemer, Chris, 1, 134, 437, 467
Grimm, Adrian, 254
Grinnell, Frederick, 237
Grooms, Ain, 477
Grooms, Jonathon, 182, 183
Groß, Jorge, 458, 459
Großmann, Leroy, 141
Grubb, Derrick, 380
Grybko, Tamara, 57
Guda, Ramakrishna, 232
Guerrero, Brenda, 294
Guerrero, Gonzalo, 8
Gunckel, Kristin, 354
Gunter, Glenda, 217
Guo, Shuchen, 326
Gupta, Preeti, 66
Gutierrez, Kristie, 268, 275, 464
Guy-Gaytàn, Candice, 62, 63, 79
Guyot, Michael, 374
Gyles, Symone, 390
Haas, Alison, 146, 323
Habashi, Janette, 23
Habenicht, Stefanie, 374
Habig, Sebastian, 124, 190, 197
Hadas, Boaz, 266
Haddad Lingle, Jennifer, 114
Hadinezhad, Shafagh, 14
Haemmerle, Linda, 422
Hagan, Claudia, 174
Hagevik, Rita, 76, 345
Hahs-Vaughn, Debbie, 217
Haines, Sarah, 91
Halama, Katherine, 543
Halasa, Katrina, 115
Hale, Karla, 153, 304, 468
Hall, Amanda, 96, 144, 396, 525
Hall, Jonathan, 162, 486
Hall, Kevin, 42, 247
Hamada, Emily, 520
Hamdan, Alia, 128
Hamm, Jill, 89
Hammack, Rebekah, 49, 276, 511
Han, Sisi, 73
Hancock II, James, 240
Hand, Brian, 143, 278, 369, 517
Handler, Robert, 60
Hanedar, Melike, 9
Hanley, Dan, 347
Hansen, Alexandria, 142, 523
Hansen, Tyler, 154, 493
Hanuscin, Deborah, 41, 309, 404
Hapgood, Susana, 246
Happel-Parkins, Alison, 312
Harbison, Monet, 219
Hardin, Stacey, 298
Hardy, Michael, 292
Harlow, Danielle, 401

Harms, Ute, 82, 164, 166, 430
Harold, Sera, 407
Harper, Lauren, 131
Harper-Gampp, Tyler, 359, 360, 501
Harris, Christopher, 384
Harris, Emily, 62, 63, 158, 192
Harrold, Archer, 123
Harwood, Amanda, 240
Hashky, Amal, 224
Hasseler, Elizabeth, 379
Hatzfeld, Jon, 29
Haudek, Kevin, 70, 71
Haugland, Sydney, 462
Haverly, Christa, 198, 246
Hayes, Kathryn, 158, 243
Hayes, Meredith, 516
Hays, Karen, 350
Hazari, Zahra, 327, 329
He, Cheng-Wen, 234
He, Peng, 46, 71, 216, 384
He, Xinyu, 71
Heeringa, Krista, 416
Hefty, Nicole, 525
Heinicke, Susanne, 368
Hemmerich, SJ, 477
Henderson, Trevion, 444
Hendren, Christine, 400
Henrie, Andrea, 273, 376, 534, 535
Henze, Ineke, 498
Herman, Benjamin, 41, 75, 332, 363, 502, 513
Herrick, Imogen, 345
Herring, Hada, 371
Herrmann Abell, Cari, 79, 148, 149, 175, 269, 307, 530
Heuckmann, Benedikt, 491
Hewitt, Krissi, 77
Hieb, Jeffrey, 317, 537
Hiester, Peter, 158
Hiniborch, Julia, 397
Hinman, Tierney, 375
Hira, Avneet, 346
Hirni, Megan, 203
Hirst Bernhardt, Christine, 316
Hite, Rebecca, 271
Hiwatig, Benny Mart, 112
Hlazo, Noluthando, 340
Hoda Wilkerson, Michelle, 259
Hoffmann, Jakob, 397
Hokayem, Hayat, 45, 205, 221, 370
Holbrook, Jack, 187, 263, 393
Holincheck, Nancy, 353
Holland, Kurt, 469
Holmegaard, Henriette, 68, 329
Holochwost, Steven, 150
Holt, David, 258
Holt, Emily, 316, 500
Hong, Minju, 244, 262
Honwad, Sameer, 424
Hood, Angela, 182, 183
Hopp, Rachel, 317
Horak, Maria, 410
Horgan, Jacqueline, 138
Horn, Lani, 33
Hoston, Douglas, 254
Hott, Jaika, 382
Hovhenessian, Cara, 219
Howard, Rob, 383
Howes, Elaine, 242, 433
Hsi, Sherry, 79
Hsu, Samantha, 374
Hu, Xiaochen, 373
Huang, Hui-Ju, 302
Huang, Mingchun, 46, 216
Huang, Xiao, 334
Huang, Yuxi, 176, 177, 398
Hubbard, Malissa, 354
Hudson, Michelle, 352
Hug, Barbara, 167, 247, 248, 249, 467
Hug, Sarah, 293
Hughes, Brad, 539
Hughes, Roxanne, 298
Hung, Ching-Sui, 473
Hunter, Ally, 373
Hunter, Ashley, 380
Hunter, Joshua, 339
Hunter, Roberta, 319, 435, 489
Hussein, Manar, 179

Hutcheson, Nathan, 332
Hwang, Jiwon, 251
Hylton, Brandon, 281
Ibourk, Amal, 159, 391, 542
Ibrahim, Bashirah, 18, 26
Ibrahim, Mohammed, 445
Ibukunolu, Ademola, 101
Ideus, Kimberly, 106
Idsardi, Robert, 180, 405, 519
Ikpah, Chinyere, 101
Inouye, Martha, 276
Irish, Tobias, 155
Irizarry, Yasmiyn, 385
Irwin, Chris, 382
Irwin, Christopher, 127, 327
Isaacs, Raina, 317
Itodo, Ann, 509
Ivelan, Ashley, 275, 490
Iveland, Ashley, 275, 490
Jaber, Lama, 2, 274, 366, 370
Jackson, Jennifer, 67, 303
Jackson, Katelynn, 524
Jacobs, Jennifer, 111, 149, 211
Jadallah, Christopher, 389
Jamieson, Marnie, 135
Janney, Ben, 41
Janney, Benjamin, 139, 502
Janumyan Doe, Yelena, 390, 496
Jarosewich, Tania, 247
Jasper, Summer, 313, 402
Jen, Tessaly, 390, 534
Jenkins, Austin, 456
Jensen, Jess, 523
Jeong, Sophia, 273, 376, 535
Jess, Carolyn, 523
Jimenez, Bree, 303
Jiménez-Liso, María, 265
Jimenez-Silva, Margarita, 12
Jin, Hui, 169
Jin, Jing, 362
Jin, Qingna, 106, 135, 394
Jita, Loyiso, 4, 205, 394, 441
Johann, Leonie, 458
Johari, Marlizayati, 155
John, Kenesma, 358
Johnson, Bruce, 193
Johnson, Candice, 72, 349
Johnson, Carla, 69, 407
Johnson, Heather, 320, 376, 534, 535
Johnson, Jake, 399
Johnson, Lindy, 471
Johnson, Odis, 250
Johnson, Wendy, 288, 311
Jones, Gail, 131
Jones, Harmony, 255
Jones, Latrice, 314
Jones, M. Gail, 43, 106, 131, 400, 526
Jones, Melissa, 20
Jones, Ryan, 87, 119
Jordan, Michelle, 294, 341
Jornet, Alfredo, 261
Joshi, Arti, 225
Ju, Liang, 293
Juárez, Thalía, 9
Judson, Eugene, 445
Jung, Hyunyi, 358
Jung, Jin Kyeong, 268
Juuti, Kalle, 64
Kaderavek, Joan, 246
Kaldaras, Leonora, 70
Kamdar, Danae, 519
Kampourakis, Kostas, 495
Kanagaki, Niki, 517
Kang, Hosun, 186, 493
Kao, Yu-Chia (Irene), 137
Kao, Yvonne, 470
Kapsala, Nausica, 333
Karaer, Funda, 160
Karch, Jessica, 425, 426
Karumanthra, Arya, 339, 508
Kashef, Shahin, 508
Kasneci, Enkelejda, 255
Kasseboehmer, Ana, 356
Kasuk, Heili, 263
Katende, Samuel, 296
Kaur Bharaj, Pavneet, 252, 301, 447
Kavanagh, Kathryn, 137
Kawasaki, Jarod, 469

Kaya, Ebru, 73
Kaya, Erdogan, 157, 191
Kaya, Erogan, 191
Kaya, Ruveyde, 178
Ke, Li, 129, 277, 367
Kearney, Matthew, 488
Keas, Brian, 423
Keen, Clarissa, 428
Keifert, Teo, 376, 535
Kellberg, Sarah, 138
Keller, Melanie, 138
Kelles, Ludmila, 265
Kelly, Angela, 11, 29, 170, 188, 229, 286, 326, 343, 351, 429, 527
Kemmis, Stephen, 209
Kennedy, Ben, 472
Kenyon, Lisa, 38, 145
Kershner, Mark, 164
Ketelhut, Diane, 24
Kettle, Nathan, 416
Khan, Nazia, 540
Khan, Samia, 378, 529
Khan, Sheliza, 8
Khishfe, Rola, 541
Khushal, Anum, 232, 235
Kidd, Aaron, 363
Kidd, Jennifer, 275
Kier, Meredith, 471, 478
Killen, Heather, 336
Kim, Anna, 349
Kim, Boyun, 207
Kim, Candice, 253
Kim, Chan-Jong, 17
Kim, Kiho, 300
Kim, Mijung, 106, 135
Kim, Won Jung, 7, 24
Kim, Young Ae, 207, 321, 506
Kind, Vanessa, 43
King, Natalie, 41, 329, 372, 434, 479
Kinsey, Devon, 517
Kinskey, Melanie, 36
Kirby, Caitlin, 368
Kirchgasler, Kathryn, 221
Kirk, Eric, 83, 129, 277, 367
Kirkland, Rena, 11
Kirkpatrick, Catherine, 30
Kirstein, Kimberly, 403
Kitsantas, Anastasia, 281
Kizys, Denae, 314
Klaib, Melissa, 431
Klasik, Daniel, 77
Klavon, Timothy, 462
Klein, Emily, 298
Klein-Avraham, Inbal, 3
Klemetsrud, Bethany, 511
Kloser, Matthew, 274
Kluckman, Elizabeth, 96
Klukowski, Lori, 87, 119
Knain, Erik, 261
Knox, Tryna, 116
Ko, Monlin Monica, 247, 249
Koberstein-Schwarz, Maren, 142
Koch, Amanda, 91
Koh, Do Hyong, 330
Kohlmeier, Sonja, 414
Koirala, Kamal, 391, 533
Kõlamets, Lauri, 263
Kolovou, Maria, 156
Kooman, Michelle, 338
Korb, Michele, 175, 207, 302, 506
Korfiatis, Konstantinos, 476
Kosiur, K, 224
Koskey, Kristin, 115
Kotler, Rebecca, 156
Koukoulidis, Niki, 279, 536
Kouzeli, Ariadni, 228
Kovacich, Katie, 481
Kowalski, Susan, 383
Krajcik, Joe, 289
Krajcik, Joseph, 46, 70, 71, 104, 146, 216, 311
Krakehl, Robert, 11, 29, 229
Krall, Rebecca, 318
Kramarczuk, Kristina, 24
Krause-Wichmann, Theresa, 422
Krell, Moritz, 141, 325, 378
Kremer, Joe, 300
Kremer, Kerstin, 362, 491

Kresin, Soraya, 20
Krimitzas, Antonios, 495
Krishnamoorthy, Rishi, 341
Krishnan, Harini, 35, 370, 497
Krishnan, Sandhya, 171, 472
Krist, Stina, 2, 42, 168, 247, 248, 249, 320, 337, 467
Krüger, Dirk, 129, 141, 142
Kruse, Jerrid, 540
Kubsch, Marcus, 42, 82, 222, 254, 337, 382
Kudumu, Mwenda, 128
Kuhlmann, Shelbi, 422
Kulasingam, Robert, 360, 361
Kulgemeyer, Christoph, 140
Kulp, Kelly, 180, 520
Kunz, Kadie, 236
Kunze, Rebecca, 20
Kuo, Eric, 527
Kuper, Olivia, 271
Kusnick, Judith, 136
Labadorf, Adam, 347
Lacy, Sara, 262
Lahiri, Shweta, 259, 335
Laikram, Gamolnaree, 315
Laius, Anne, 450
Lamb, Richard, 224, 254
Lampert, Peter, 192
Lamy, Berry, 127
Landwehre, Emily, 497
Lane, Jim, 227
Lane, Kady, 301
Lane, Kelly, 69, 485
Lane, McKenna, 166
Lane, W. Brian, 422
Langbeheim, Elon, 278
Langewisch, Tiffany, 331
Langman, Juliet, 521
Lanouette, Kathryn, 159, 190
Lardy, Corinne, 175, 302
Larimore, Rachel, 38
Larkin, Douglas, 77, 179, 366, 534
Larson, Rachel, 224
Latif, Ehsan, 71
Laumann, Daniel, 368
Lavender, Heather, 522
Lavigne, Cheryl, 416
Lavonen, Jari, 47, 64, 118
Lawson, Michael, 345
Lazenby, Katherine, 383
Le, Paul, 293
Lê, Thanh, 233, 374
Leammukda, Felicia, 122
Leary, Heather, 352
Leary, Michael, 269
Leauthaud, Alexie, 402
Lederman, Judith, 257
Lee, Dennis, 150
Lee, Gyeong-Geon, 337, 414
Lee, Hee Rin, 104
Lee, Hee-Sun, 529
Lee, Heewoo, 83, 307, 480
Lee, Irene, 52, 314
Lee, Jane, 384
Lee, Kyung Sook, 86
Lee, Meng-Chin, 161
Lee, Minjung, 275
Lee, Okhee, 146, 324, 533
Lee, Samuel, 63, 147
Lee, Sarah, 376, 534, 535
Lee, Soon, 239, 343
Lee, Yew-Jin, 530
Legitime, Sybille, 214
Leihsing, Samantha, 357
Lemmi, Catherine, 221
Lemons, Paula, 234
Leon, Maricela, 221
Leonard, Justin, 381
Leonardi, Nicholas, 167, 248
Leos, Victor, 61
Leowardy, Miechie, 530
Leslie, Debbie, 385
Lesnefsky, Rebecca, 215, 307, 367, 480
Lester, Monique, 90
Letloenyane, David, 4
Levendusky, Anne, 378
Levin, Daniel, 173
Levrini, Olivia, 81
Lewalter, Doris, 139

Lewis, Elizabeth, 273, 379
Lewis, Fay, 116
Lewis, Rebecca, 323
Lewis, Suzanne, 65
Li, Chunmi, 242
Li, Min, 125
Li, Tingting, 70
Li, Xingda, 448
Lieberei, Tobias, 141
Lightner, Lindsay, 309, 413
Likely, Rasheda, 543
Lilly, Sarah, 31
Lim, Slki, 89
Lima, Cynthia, 301
Lima, Nathan, 265
Lin, Huann-shyang, 134
Lin, Jing, 500
Lin, Tzu-Jung, 264
Lincoln Seets, Rachel, 523
Lindemann, Anna, 392
Lindsay, William, 210
Linn, Marcia, 15
Lipka, Jerry, 34
Lisene, Nthooa, 441
Lishinski, Alex, 233
Little, Emily, 474
Littrell, Megan, 55, 56, 57
Liu, Conghui, 49, 474
Liu, Enshan, 326
Liu, Ming, 412
Liu, Ruohan, 60
Liu, Shiang-Yao, 83, 161, 309
Liu, Xingfeiyue, 264
Liu, Xiufeng, 93, 312, 338, 407, 496
Liu, Yixuan, 241
Livingston, Melissa, 304, 468
Lo, Abraham, 63, 79, 147, 149, 175, 437
Lo, Stanley, 195, 493
Locke, Sharon, 72
Lodge, Wilton, 324, 357
Lombardo, Luciana, 170
Long, Christopher, 540
Long, MaryAnn, 427
Long, Tammy, 317
Longhurst, Max, 352, 506
Longo, Laura, 343
López Burgos, Viviana, 98, 484
López, Víctor, 51
Lore, Christopher, 529
Lossjew, Jannik, 82
Lott, Kimberly, 342
Lotter, Christine, 314
Lottero-Perdue, Pamela, 80, 517
Louie, Josephine, 528
Louis, Vanessa, 434
Lowell, Benjamin, 147, 211
Lownsbery, Douglas, 29
Lu, Chunming, 448
Lu, Yu-Ling, 395
Lucas, Lyrica, 235
Luehmann, April, 536
Luft, Julie, 60, 108, 177, 179, 180, 259, 335, 380, 398, 406, 519
Luna, Melissa, 322
Lundgren, Lisa, 236
Lundsgaard, Morten, 528
Lussier, Catherine, 431
Lux, Nicholas, 49
Ly, Le Quan, 488
Ly, Nathaniel, 331
Lyon, Edward, 302
Maasen, Aihanh, 258
Mabour, Clara, 218
MacCormac, Amanda, 532
Machado, Mercedes, 358
Machaka, Nessrine, 168, 320
Machleid, Alexander, 414
Macias, Meghan, 275
Mackenzie, Taylor, 524
MacPherson, Anna, 355
Madden, Lauren, 225, 287
Mader, Jessica, 387
Madkins, Tia, 199, 385, 419
Madsen, Lene, 68, 329
Maeng, Jennifer, 60
Mafugu, Tafirenyika, 240, 394
Magee, Nathan, 287
Maggiore, Nicolette, 425, 521

Mahapatra, Swarna, 366
Mahler, Daniela, 104
Mahmood, Maggie, 351, 527
Mahmud, Anina, 94, 252, 447
Mak, Janice, 24, 35
Makki, Nidaa, 115
Makori, Hildah, 38
Malik, Hamza, 128, 137, 319, 450, 503
Malm, Rie, 472
Malone, Danielle, 224, 413, 471
Maltese, Adam, 49, 301
Malyukova, Anna, 92
Mamlok-Naaman, Rachel, 263
Mang, Ha My Anna, 17
Mangogna, Christopher, 463
Mansell, Kristin, 518
Mansour, Nasser, 267
Manz, Eve, 2, 184, 185
Mao, Mengyi, 89
Marbach-Ad, Gili, 316, 528
Margini, Mamoun, 224
Margolin, Jonathan, 470
Marigo, Alessia, 283, 517
Marin-Rothman, Stephanie, 483
Marion, Joey, 231
Marquez-Mendez, Mayra, 245, 538
Marshall, Anna, 400
Marshall, Karen, 446
Marshall, Stefanie, 225, 477
Martin, Jenny, 514
Martin, Jonathan, 330
Martin, Lisa, 207
Martin, Sonya, 17, 30, 419
Martinez, Adriana, 72
Martinez-Cortes, Janeth, 522
Marvez, G.R., 218, 443
Maryboy, Nancy, 55
Mason, Hillary, 484
Massarani, Luisa, 204
Massey, Teresa, 128
Masters, Jeffery, 317
Mat Noor, Mohd Syafiq Aiman, 155
Mathenge, Ruth, 359, 360, 361
Mathis, Clausell, 410
Matkin, Gina, 379
Mavrikaki, Evangelia, 333
Maxey, Ebonee, 151
Maxwell, Danielle, 123
Maxwell, Tricia, 283, 517
May, Katy, 20
May, Toni, 407
Mayer, Brooke, 400
Mayes, Robert, 235
McAlister, Anne, 31
McAuliffe, Carla, 214
McCall, Heather, 481
McCance, Katherine, 52
McCarthy Hintz, Mary, 136
McCausland, Jonathan, 67, 279
McClain, Jessica, 410
McCormick, Mia, 55
McCurdy, Regina, 127, 163, 419
McDonald, Scott, 303, 310
McDonald, Shelby, 350
McDonald, Steve, 400
McElhaney, Kevin, 519
McFeetors, Janelle, 135
McGee, Steven, 276
McGill, Monica, 37
McGlamery, Sheryl, 295
McGowan, Brain, 385
McGowan, Brian, 385
McGowan, Jill, 516
McGowan, Veronica, 341
McGrail, Christine, 421
McGuire, Keon, 203
McIlwain, Charlton, 194
Mckeen, Haley, 281
McKenna, Thomas, 347
Mckenzie, Valerie, 472
McLaughlin, Gozde, 348
McLoughlin, Eilish, 413
McManus, Shannon, 436
McMillan, Elizabeth, 521
McNeal, Peggy, 460
McNeill, Katherine, 63, 147, 211, 277, 436, 467
Meehan, Sinead, 219, 461

Meeks, Amber, 106, 526
Mehta, Smriti, 182, 184
Meier, Valerie, 208
Meisert, Anke, 142
Mejia, Joel, 218
Melagonitou, Anastasia, 333
Melton, Josie, 347, 404
Mendenhall, Melissa, 342
Méndez Pérez, Karina, 186, 220
Menekse, Muhsin, 217
Menon, Deepika, 91, 92, 460
Mensah, Adjoa, 245, 538
Mensah, Felicia, 67, 138, 226, 329
Mentesoglu, Zeynep, 369
Mercier, Alison, 50, 114, 375
Merritt, Joi, 36
Mesiner, J, 173
Messig, Denis, 458
Metcalf, Allison, 2, 456
Metcalf, Leah, 89
Metzger, Christy, 136, 466
Meyer, André, 266, 414
Meyers, Erica, 122
Meza-Torres, Carlos, 294, 340, 341
Michal, Zion, 319
Michele, Korb, 206
Michelsen, Malte, 459
Mikeska, Jamie, 283, 301, 337, 404, 517
Miller, Alison, 38
Miller, Brian, 7
Miller, Bridget, 91
Miller, Britt, 223
Miller, Brittany, 281
Miller, Cory, 146
Miller, Hannah, 311
Miller, Jadda, 319
Miller, Jocelyn, 268
Miller, Kate, 432
Miller, Katie, 517
Miller, Seneca, 237
Miller, Soren, 271
Miller-Rushing, Anica, 114
Millner, Amon, 219
Milne, Safron, 123
Milner-Bolotin, Marina, 308
Min, SungEun, 475
Minocha, Suhina, 52
Minocha, Trisha, 87
Minogue, James, 532
Mirabete, Glen, 22
Mitapalli, Kavita, 152
Mitchell, Arion, 353
Mitchell, Nathan, 156
Mitzel, Edmund, 182, 183, 184
Moeller, Andrea, 108, 193, 422
Moga, Collins, 371
Mohammad Isa, Izzah Mardhiya, 4
Mohan, Audrey, 62
Mohan, Lindsey, 62, 64, 79, 192
Mohorn-Mintah, Olayinka, 162, 312, 313
Monahan, Robert, 532
Monroe, Martha, 364
Monteith, Barnas, 223
Montoya, Aaron, 11
Moore, Austin, 147, 436
Moore, Katherine, 313
Moore, Tamara, 284
Morales, Consuelo, 384
Morales-Doyle, Daniel, 34
Morandi, Sierra, 178, 244, 456
Moreira Seguel, Patricia, 321
Morell, Linda, 272, 354, 355
Morena Vera, Maria, 436
Moreno Vera, Maria, 147, 277
Moreno, Nancy, 526
Morrison Thomas, Christie, 212
Morrison, Amanda, 305
Morrison, Deb, 159, 160
Morrison, Judith, 413, 471
Morton, Terrell, 33, 385
Moss-Barber, Angela, 350
Moura, Cristiano, 329
Mrakuzic, August, 55
Muchson, M, 133
Mueller, Andreas, 495
Mulcahy, Marian, 357
Muller, Alexandria, 127, 128, 163, 401
Müller, Sophie-Luise, 104

Mulvey, Bridget, 34
Munakata, Mika, 298
Muñoz, Mayra, 77, 179
Munsell, Jeremy, 372
Murray, Jaclyn, 521
Murthy, Sahana, 495
Mutegi, Jomo, 252
Nag Chowdhuri, Meghna, 172, 524
Nageotte, Nichole, 350
Nagy, Chelsea, 543
Namakula, Esther, 157, 301
Nancy, Sharfun Islam, 428
Nanthou, Delwrick, 410
Nardo, Jocelyn, 426
Nassar, Souhaila, 184
Nation, Jasmine, 469, 523
Navarrete, Kasandra, 97
Navas Iannini, Ana Maria, 89
Navy, Shannon, 12, 179, 180, 405, 519
Nehm, Ross, 165
Neito, Rauno, 118
Nelson, Brian, 24
Nelson, Eva, 297
Nelson-Barber, Sharon, 34, 338
Nerdel, Claudia, 255
Neumann, Knut, 82, 254, 382
Newbutt, Nigel, 138
Newcomer, Sarah, 413
Newell, Alana, 526
Newton, Mark, 195, 447
Nguyen, Hai, 203
Nguyen, Sarah, 422
Nichols, Bryan, 507
Nicholson, Louise, 125
Nickel, Sebastian, 124
Nielsen, Katherine, 245
Niemann, Jonas, 482
Nieuwsma, Julianna, 106, 131, 400
Nieves, Kristina, 164
Nilsen, Katherine, 490
Nilsen, Katy, 270, 490
Nilsson, Pernilla, 64, 499
Nimrod, Batzon, 319
Nipyrakis, Argyris, 413
Nissen, Jayson, 250, 374
Nixon, Jessie, 211
Nixon, Ryan, 174, 239
Nizomov, Javlon, 374
Noble, Samanthia, 271
Nolan, Eric, 158, 475
Noll, Jamie, 300
Norberto, Jessica, 163
Nordine, Jeffrey, 64, 138, 310
Nordstrom, Susan, 313
Nouri, Noushin, 25
Noyce, Penny, 181
Nuñez, Paola, 97, 105
Nuss, Sarah, 365
Nyachwaya, James, 271
Nyaema, Mary, 440
O'Connor, Dawn, 243
O'Connor, Keelin, 148, 149
O'Meara, John, 298
O'Neill, Tara, 514
Oancea, Alis, 257
Odeleye, Oluwatobi, 270
Odom, Ailee, 364
Oehm, Nicholas, 127
Ofek-Geva, Ella, 393
Ogawa, Tomoka, 173
Ogonenwe, John, 537
Ogundapo, Taiwo, 301
Ogunlade, Ibiyinka, 101, 238
Ogunniyi, Meshach, 435
Oka, Lalita, 250
Okan, Beyza, 452
Okebukola, Peter, 28, 47, 101, 201, 238, 282, 397, 449, 509, 531, 537
Okochi, Christine, 55, 56, 57
Okorie, Henry, 28
Oladeje, Adekunle, 101
Oladejo, Adekunle, 28, 201, 238, 282
Olitsky, Stacy, 124, 501
Olivares, Maria, 219
Olson, Alister, 513
Olson, Joanne, 226, 377
Olson, Melissa, 268
Olson, Patricia, 307, 530

Olsson, Daniel, 192
Omara, Ehab, 381
Omokongbe, Modupe, 510
Onowugbeda, Franklin, 101, 201, 282, 449
Onyancha, Whitney, 497
Opps, Zac, 169
Orozco-Franco, Estefania, 233
Orru, Hans, 476
Ortega, Jessica, 328
Ortiz, Miriam, 196
Ortiz, Nickolaus, 385
Osborne, Jonathan, 181
Osborne, Melisa, 347
Osgard, Faith, 65
Osheroff, Hilleary, 350
Otero, Kristina, 217
Otero, Valerie, 210
Ottenbreit-Leftwich, Anne, 284
Owens, David, 169, 338, 403
Oyewole, Peter, 85
Ozen, Hatice, 177, 380
Ozturk, Sonnur, 199
Ozulku, Elif, 178, 244
Ozyazici, Gizem, 502
Pacheco, Mark, 371, 536
Padolf, Amy, 152
Paine, Spencer, 469
Painter, Jason, 96, 144, 396, 525
Paksoy, Ipek, 10
Palaguachi, Chris, 42
Palermo, Martin, 229
Pallant, Amy, 529
Palmer, Robert, 203
Palmer, Tracey-Ann, 488
Pannella, Robyn, 402
Para Camacho, Francisco, 99
Parikh, Tapan, 190
Park Rogers, Meredith, 94, 301, 463
Park, Byung-Yeol, 392
Park, Hyoung Joon, 126
Park, Jaesung, 493, 494
Park, Jongchan, 340, 341
Park, Julie, 203
Park, Mihwa, 36
Park, Soonhye, 95, 96, 135, 144, 232, 267, 396, 404, 525
Park, Sunyoung, 244
Park, Wonyong, 513
Parker, Carolyn, 182, 300
Parraguez, Carolina, 105
Parslow, Michelle, 76, 344
Passentin, Shira, 132, 307, 480
Passmore, Cindy, 1
Passmore, Cynthia, 134, 269, 437, 467, 530
Patel, Maya, 410
Patrick, Patricia, 90
Pattison, Scott, 98, 484
Patzelt, Suzanne, 77, 100, 179
Pavez, José, 176, 180, 520
Pavlovich, Chris, 74, 299
Pearcy, Melissa, 224
Pecore, John, 255
Pedretti, Erminia, 89
Peel, Amanda, 195, 276
Peeters, Hendrik, 190
Peleg, Ran, 172
Pellegrino, James, 439
Peña-Telfer, Laura, 329, 479
Peng, He, 46
Pennella, Robyn, 208, 313
Pennycook, Daniela, 55
Penuel, William, 1, 134, 148, 437
Pérez, Greses, 80, 218, 443
Perez, Leticia, 119, 399
Perkins, Kathy, 288
Perl-Nussbaum, David, 144
Perret, Beatriz, 52, 326
Peter, David, 47
Peter, Esther, 47, 282, 397
Petermann, Verena, 143
Peters, Lacey, 23
Peters-Burton, Erin, 223, 281
Peterson, Emily, 350
Peterson, Kirsten, 52
Peterson, Matthew, 359, 360, 361
Petrosino, Anthony, 504
Petter, Arne, 140
Pham, Duy, 283

Phang, Fatin Aliah, 4
Phatak, Jaai, 345
Phillips, Andrea, 94, 463
Piedrahita, Yuri, 170
Pierre, Takeshia, 252, 358
Pierson, Ashlyn, 273, 341, 375, 535
Pietrocola, Mauricio, 81
Pikus, Arianna, 86
Pimentel, Daniel, 181, 363, 398
Pinar, Fredyrose Ivan, 132
Planchart, Rebecca, 360
Pleasants, Jacob, 191, 285
Plumley, Courtney, 324
Plummer, Julia, 204, 366
Poel, Julia, 167
Polanco Pino, Ymbar, 218
Pomian Bogdanov, Katarzyna, 442
Pomplun, Marc, 330
Poor, Sarah, 41, 332, 363
Popov, Oleg, 476
Porter, Sara, 350
Pospiech, Gesche, 231
Potes, Stacy, 339
Powell, Wardell, 121
Powers, Tamara, 41, 332, 502
Praisri, Anupong, 529
Prasad, Priyadharshini, 330
Prasoplarb, Tharuesean, 466
Preminger, Linda, 243
Price, Nancy, 160
Price, Paula, 385
Prijoles, Alexis, 383
Prince, Adepeju, 164, 179, 180, 520
Priyadarshini, Rajashri, 495
Pshenichny-Mamo, Anna, 105
Pugh, Priya, 536
Pugh, Zachary, 224
Puntambekar, Sadhana, 14
Purwanto, Muhammad, 421
Purzer, Senay, 80, 476
Putro Utomo, Anjar, 498
Puttick, Gillian, 353
Puvirajah, Anton, 359
Qazi-Lampert, Ayesha, 156
Quarderer, Nathan, 543
Quijano, María, 484
Quinlan, Catherine, 34
Quintero, Karen, 364
Race, Alexandra, 424
Rachmatullah, Arif, 24, 470
Radloff, Jeffrey, 91
Rafanan, Ken, 326
Ragan, N. Scott, 96, 144, 396, 525
Ragonese, Andrea, 204
Ragoub, Sarah, 74, 482, 492
Ragusa, Gisele, 326
Rahman, Muhammad, 330
Rahman, S M Hafizur, 264, 280
Rahman, Shukufe, 339, 474
Rahman, Tunde, 537
Rajwade, Aparajita, 261
Rambo-Hernandez, Karen, 483
Ramirez Villarin, Lorraine, 88
Ramirez-Salgado, Andrea, 284
Ramos Montañez, Smirla, 98, 484
Ramsey, Jefferson, 89
Rannikmäe, Miia, 65, 187, 197, 393
Rao, Asha, 41, 363
Rap, Shelley, 292, 406
Raphael, Daniel, 345
Ratcliff, Andrea, 481
Rathore, Surbhi, 224
Rattling Leaf, James, 543
Rauf, Abdul, 54
Rayelynn, Brandl, 74
Reaves, Jessica, 239
Rebello, Carina, 170, 372
Rebello, N, 171
Rebello, Sanjay, 372
Reck, Cathrine, 415
Recker, Mimi, 211
Reeder, Andrea, 456
Refvem, Emma, 526
Rego, Melissa, 490
Reich, Christoph, 165
Reigh, Emily, 213
Reinisch, Bianca, 325
Reisch, Joan, 237

Reiser, Brian, 1, 134, 168, 437, 467
Reiser, Markus, 201
Reiska, Priit, 197, 413
Reiss, Michael, 324, 357
Reivelt, Kaido, 118
Relkin, Emily, 470
Rempel, Brian, 123
Rende, Ren, 69, 128
Resasco, Julian, 472
Reynolds, Matt, 96, 144, 396, 404
Reynolds, Scott, 418
Reynolds, W. Matthew, 96, 144, 396, 404, 452, 525
Rhemer, Danielle, 178, 275
Rich, DelVechio, 534
Rich, Peter, 281
Richards, Cameron, 481
Richards, Jennifer, 213, 322
Richland, Lindsey, 539
Richmond, Gail, 319, 435
Ricketts, Amy, 206
Riffel, Alvin, 340
Riggs, Kadence, 53
Rillero, Peter, 12, 512
Ringstaff, Cathy, 276
Riordan, Brian, 169
Ritchie, Marisa, 469
Ritzhaupt, Albert, 330
Rivera Maulucci, Maria, 241
Rivera, Seema, 478
Rivera-Jiménez, Sindia, 443
Robinson, Carla, 186
Robinson, Julie, 276, 338, 510, 511
Robinson-Hill, Rona, 162, 453
Rock, Ronan, 156
Rodriguez, Shelly, 479
Roehrig, Gillian, 191, 234, 260, 421
Rojas, Diego, 79, 300
Rojas-Perilla, Diego, 300
Rokenes, Hanna, 261
Rolle, Chelsea, 53
Román, Diego, 221
Romine, William, 460
Ron, Blonder, 406
Rongstad Strong, Brigitta, 55, 57
Ropohl, Mathias, 64
Rosato, Jennifer, 37
Rose, Kerry, 135
Rosenberg, Jessica, 353
Rosenberg, Joshua, 42, 216, 233
Rosenberg, Paola, 186
Rosin, Triin, 65
Roslan, Roslinawati, 155
Rouinfar, Amy, 288
Rowe, Shawn, 204
Roy, Pooja, 167
Rozhenkova, Veronika, 117
Rubalcava, Isabella, 402
Rüger, Theresa, 347
Ruggirello, Rachel, 30
Rummel, Nikol, 82, 254
Rusk, Fredrik, 458
Russell, Mia, 353
Russo-Tait, Tatiane, 328, 346
Rutt, Alexis, 535
Rutter, Erica, 250
Ryu, Minjung, 54
Saarna, Rolf, 450
Saberi, Maryam, 25
Sachs, Lindsey, 516
Sadidi, Farahnaz, 231
Sadler, Philip, 293, 327
Sadler, Troy, 34, 77, 83, 84, 129, 215, 226, 227, 277, 307, 366, 367, 480
Saefi, Muhammad, 133
Saenz, Laura, 38
Safley, Sarah, 516
Sager, Marc, 504
Saha, Sriparna, 472
Sahin, Adam, 344
Sahin, Burak, 386
Sahin, Emine, 431
Sahin, Ercin, 143, 369, 517
Sahin-Topalcengiz, Emine, 431
Said, Hardimah, 155
Saint-Hilaire, Line, 92
Saleh, Mounir, 18
Salguera, Samantha, 402

Samari, Somayeh, 25
Sample McMeeking, Laura, 387
Sampson, Blake, 541
Sanchez, Anastasia, 341
Sanni, Rasheed, 101
Sanovia, James, 543
Sansom, Rebecca, 352
Santibáñez, David, 105
Sargeant, Stephanie, 116
Sarkonak, Christopher, 306
Sato, Brian, 118
Saville, Elizabeth, 100, 308
Saw, Guan, 509
Sbeglia, Gena, 165
Scalfi, Graziele, 204
Schaecher, Annamarie, 57
Schafer, Alysa, 68
Schafer, George, 219, 280
Schäfer, Xenia, 197
Schaffer, Kristen, 253
Scharen, Danielle, 516
Schectman, Emma, 319
Scheer, Madison, 387
Schiering, Dustin, 64
Schlendorf, Christine, 11
Schmidt, Elvira, 362
Schneble, Dominik, 352, 429
Schoenfeld, Ilana, 103
Scholl, Daniel, 142
Schönle, Daniel, 165
Schoute, Eric, 214
Schramme, Charlotte, 325
Schuchardt, Anita, 30, 234, 260
Schultz, Carrie, 139
Schussler, Elisabeth, 233
Schwartz, Renee, 257, 258, 474
Schwarz, Baruch, 144
Schwarz, Christina, 86, 169, 377, 419
Schwendemann, Meredith, 379, 380
Schwenger, Abigail, 146, 324
Schwiesow, Melissa, 462
Scipio, Déana, 536
Scoggin, Sylvia, 65
Scott, Emily, 311
Scott, Fonya, 87, 119
Scott, Lyn, 302
Secules, Stephen, 444
Sedawi, Wisam, 172
Sedlacek, Quentin, 221
Seeber, Emily, 246
Segal, Natasha, 198, 307, 480
Semilarski, Helen, 107, 392, 441
Semilarski, Helin, 107, 392, 441
Sengul, Ozden, 8
Seßler, Kathrin, 255
Settlage, John, 80
Seung, Elsun, 96
Severance, Samuel, 402
Sevian, Hannah, 323, 428
Sezen-Barrie, Asli, 388, 528
Shabani, Juma, 28, 47, 101, 201, 238, 282, 397, 449, 537
Shaby, Neta, 172, 204
Shafer, Devyn, 351, 528
Shah, Barkha, 347
Shah, Sheikh Ahmad, 345
Shahat, Mohamed, 381
Shan, Pengcheng, 26
Shannon, Katheryn, 292
Sharma, Ajay, 259, 335, 475
Sharp, Katherine, 318
Shaukat, Kinza, 359
Shaw, Jerome, 305
Shea, Molly, 172
Shein, Paichi, 35, 193, 511
Shekarkhar, Zahra, 373
Shekell, Calli, 301
Shemwell, Jonathan, 177, 200
Shen, Siqi, 17, 28
Sheppard, Keith, 286
Sherard, Max, 346
Sherry-Wagner, Jordan, 341
Sherwood, Carrie-Anne, 319
Shi, Yueying, 326
Shifat, Md Nazmuzzaman, 264
Shillingstad, Saundra, 295
Shim, Soo Won, 296
Shim, Soo-Yean, 212, 247

Shin, Jennie, 337, 536
Shin, Jinnie, 536
Shin, Myunghwan, 142, 523
Shin, Namsoo, 46, 71, 216, 311
Short, Mary, 370
Short-Meyerson, Katherine, 12
Shridhar, Aishwarya, 252
Shultz, Ginger, 123
Shwartz, Yael, 130, 434
Sidawi, Wisam, 99
Siegel, Debbie, 465
Siegel, Marcelle, 203
Siegmann, Sophia, 417
Siepsiak, Monika, 286
Siggard, Reagan, 195
Simani, Maria, 213
Simon, Marsha, 128, 163
Simpson, William, 416
Sinapuelas, Michelle, 175
Sinatra, Gale, 214
Sinclair, Katie, 523
Singh, Harleen, 36, 398
Singh, Khushbu, 379, 380
Sircar, Monica, 61, 151
Sirrakos, George, 249
Siry, Christina, 5, 329
Sitt, Jason, 223
Sivaraj, Ramya, 421
Skerrett, Allison, 199
Skiebe-Corrette, Petra, 325
Skinner, Ron, 401
Skordoulis, Constantine, 333
Skoropad, Stephen, 186
Slater, Emily, 236, 493
Smirnoff, Dimitri, 260
Smith, Adrienne, 373
Smith, Blaine, 390
Smith, Caleb, 292
Smith, Clara, 352
Smith, Patrick, 131, 425, 516
Smith, Sean, 467
Snell-Rood, Emilie, 260
Snowden, Jeffrey, 79, 192, 269, 530
Sobomehin, Kendra, 388
Sobomehin, Tamara, 388
Sobotka, Alex, 513
Sodani, Danielle, 300
Solanki, Sabrina, 136
Solé, Caterina, 45
Solís, Jorge, 522
Sollinger, Jennifer, 52
Solomon, Folashade, 156
Sommer, Katrin, 504
Song, Xinhao, 241
Song, Youngjin, 207
Sonnert, Gerhard, 293, 327
Soobard, Regina, 65, 197, 393
Sorensen, Amanda, 368
Sorge, Stefan, 64, 382
Southerland, Sherry, 178, 244, 274, 370
Speirs, J. Caleb, 422
Spencer, Jeffrey, 123
Spurgin, Caroline, 302
Sroka, Georgia, 53
St. Clair, Natalya, 6
St. Louis, Alex, 460
Stadler, Matthias, 64
Stallard, Madeline, 106, 131
Stammes, Hanna, 230
Staples, Megan, 215
Stark, Louisa, 497
Starks, Elizabeth, 390
Starrett, Emily, 341
Stasinakis, Panagiotis, 495
Staus, Nancy, 204
Stavrou, Dimitris, 413
Steele, David, 33, 128, 375
Stein, Jill, 55, 57
Steiner, Elizabeth, 125
Stelzer, Tim, 527
Stennett, Betty, 62, 79, 175
Stephens, A Lynn, 6
Stephenson Reaves, Jessica, 543
Sterenberg Mahon, Alycia, 324
Stern, Florian, 495
Stern, Gal, 488
Steward, May, 356
Stewart, Matt, 315

Stoeckel, Marta, 498
Stoler, Annabel, 2
Stone, Michael, 39
Store, Jessie, 240
Storie, Monique, 155
Stouthart, Tuba, 260
Strasser, Mikayla, 520
Stretch, Elizabeth, 497
Strickland, Carla, 385
Strippel, Christian, 504
Stronach, Rachel, 137, 319, 450, 503
Strong, Alexandra, 444
Stroupe, David, 423, 432
Stuhlsatz, Molly, 269, 530
Stynen, Kathleen, 65
Su, Man, 24
Suarez, Enrique, 2
Suárez, Enrique (Henry), 2
Subramaniam, Karthigeyan, 540
Suh, Jee, 143, 369
Suh, Jee Kyung, 278, 517
Suh, Yon Soo, 383
Sukinarhimi, Peresang, 35, 511
Summers, Ryan, 17, 276
Sumner, Tamara, 111
Surman, Amanda, 502
Svarovsky, Gina, 98, 274, 436
Swanson, Kylie, 464
Swartz, Mark, 422
Sweetman, Sara, 485
Swindell, Virginia, 99, 172
Syed, Awais, 63, 150
Syifa, Mutiara, 273, 376, 456
Szopiak, Michael, 274
T, Janari, 393
T., Janari, 393
T., Talaue, 46
Tabora, Johan, 452, 456
Taddicken, Monika, 3
Tai, Robert, 223
Tal, Tali, 435
Talafian, Hamideh, 351, 527
Talanquer, Vicente, 321
Talbot, Robert, 195
Tan, Edna, 99, 172, 341
Tan, Sean, 354
Tan, Yuen Sze, 19
Tanakand, Akarat, 529
Tang, Daijazi, 344
Tank, Kristina, 284
Tanner, Quinn, 390
Tashiro, Lynn, 136
Tasquier, Giulia, 81, 261
Taylor, Graceanne, 287
Taylor, Joseph, 195
Taylor, Lezly, 478
Taylor, Monica, 298
Taylor, Scott, 472
Teessar, Janari, 393
Tekkumru-Kisa, Miray, 320, 322, 438
Ten Brink, Jared, 440
Tena, Èlia, 45
Tenbrink, Jared, 338
Teppo, Moonika, 197
Terrell Shockley, Ebony, 24, 356
Teshera-Levye, Jennifer, 451
Thacker, Ian, 357
Thayaseelan, Kannaki, 407
Thomas, Christie Morrison, 212
Thomas, Gregory, 315
Thomas, Shane, 405
Thompson, Jessica, 212, 295
Thompson, Kaci, 316
Thompson, Keith, 250
Thorsen, Gry, 68
Tierney, Jessica, 283, 517
Tillotson, John, 502
Tilsen, Jenny, 128, 306
Tissenbaum, Michael, 14
Titu, Preethi, 239
Tobin, Roger, 262
Tofel-Grehl, Colby, 94, 154, 326, 342
Tokman, Mayya, 250
Tolbert Smith, DeLean, 97
Tolbert, Sara, 388
Tominey, Shauna, 484
Topçu, Mustafa, 10, 48, 494
Topliceanu, Ana-Maria, 52

Torralba, Maria Veronica, 46
Torres Olave, Betzabe, 329
Tosun, Gozde, 128
Townley, Amanda, 287
Tramowsky, Nadine, 459
Tran, Hong, 176, 259, 281, 335, 398, 494
Tran, Khang, 250
Tran, Thao, 207
Trevino, Claudia, 409
Trinh, Andy, 493
Tripp, Jennifer, 312, 493
Trundle, Kathy, 345
Trygstad, Peggy, 131
Tsakeni, Maria, 394
Tschisgale, Paul, 42, 222
Tseng, Yu-Jan, 134
Tsugawa, Marissa, 120
Tsybulsky, Dina, 105, 488
Tuan, Hsiao-Lin, 507
Tucker-Raymond, Eli, 219
Tukurah, Grace, 387, 435, 477
Tunnicliffe, Sue, 238
Turcotte, Heidi, 258
Turner, Charlene, 440
Turner, Erin, 237
Turner, Julia, 225
Turner, Kristal, 253, 452
Turner, Ollie, 69
Tutwiler, M. Shane, 195
Tyler, Andrea, 385
Tzou, Carrie, 341, 390
Upadhyay, Bhaskar, 34, 121, 338, 391, 511, 533
Upmeier zu Belzen, Annette, 129
Urban, Rochelle, 519
Utomo, Anjar, 498
Uygun, Cansu Başak, 18
Uzun, Salih, 229
Vaino, Katrin, 65, 476
Valdez, Shelly, 55, 57
Valdmann, Ana, 476
Valerdi, Ricardo, 237
van der Veen, Jan, 261
Van Dusen, Ben, 250
Van Egeren, Laurie, 86
Van Orman, Dustin, 347
Van Wart, Sarah, 190
Varelas, Maria, 156
Varghese, Davis, 363
Varma, Keisha, 480
Vasquez, Luis, 350
Vedder-Weiss, Dana, 243, 464
Vela, Katherine, 76, 344
Velic, Lianda, 317
Venegas-Weber, Patricia, 295
Vergara, Camilo, 51
Vergara, Claudia, 97, 105
Vergara-Sandoval, Camilo, 51
Verma, Geeta, 337
Verroios, George, 495
Vilhunen, Elisa, 118
Villa, Nicole, 152
Vincent-Ruz, Paulette, 409, 427
Vivante, Irit, 464
Vo, Tina, 245, 309, 538
von Aufschnaiter, Claudia, 143
Vorholzer, Andreas, 143
Voss Farris, Amy, 348
W, Yangchunxiao, 448
W., Yangchunxiao, 448
Wade-Jaimes, Katie, 386
Wafula, Zarina, 284
Wagh, Aditi, 103
Wagner, Catherine, 99, 274, 436
Wagner, Lauren, 452, 542
Waight, Noemi, 312
Waitzman, Rotem, 266
Walan, Susanne, 499
Walker, Jennifer, 258
Walker, Justice, 33
Wallace, Jamie, 242, 433
Walsh, Maria, 296
Walters, Raven, 447
Walton, Janet, 407
Wang, Jianlan, 508
Wang, Jing, 334
Wang, Maohua, 28
Wang, Margaret, 225

Wang, Shuai, 17, 28
Wang, Wenyuan, 224
Wang, Xiaoman, 330
Wang, Xiaoyin, 381
Wang, Yangchunxiao, 448
Ward, Emily, 543
Ward, Rebecca, 20, 106
Warfa, Abdi, 112
Wargo, Jon, 515
Warren, Alison, 244
Waterman, Kevin, 528
Waters, Carol, 48, 128, 477
Watkins, Shari, 162, 300, 385, 453
Watson, Ellen, 74, 123, 306, 492
Wattier, Karliegh, 500
Waxman, Hersh, 344
Weatherton, Maryrose, 233
Weber, Douglas, 76
Weeth Feinstein, Noah, 362
Wei, Tzu-Chieh, 352, 429
Weinberg, Andrea, 387
Weindling, Monica, 150
Weinstein, Matthew, 68
Weißbach, Anna, 140
Weitzel, Holger, 201
Welberg, Julia, 368
Welter, Virginia, 141
Wendel, Daniel, 103
Wendell, Kristen, 494
Wenner, Julianne, 419, 478
Wertheim, Jill, 383, 438
Wetzstein, Lia, 481
Wheeler, Laura, 76, 345, 506
White, Bryan, 390
White, Dionne, 252
White, Peta, 181
White, Peter, 423
Whitworth, Brooke, 177, 380, 398, 419
Wieselmann, Jeanna, 91, 92, 421
Wikman, Karrie, 334
Wilhelm, Jennifer, 481
Wilkins-Yel, Kerrie, 252, 447
Williams, Mia, 50
Williamson, Francesca, 195
Wilsey, Matthew, 61
Wilson, Chris, 79, 269, 307, 530
Wilson, Makayla, 347
Wilson, Mark, 354
Wilson, Phylis, 313
Wilson, Troy, 15
Wingert, Kerri, 148, 149, 249
Wink, Donald, 440
Winter, Veronika, 108
Wirth, Joachim, 504
Witherspoon, Eben, 470
Wittmann, Beth, 69
Witzig, Stephen, 137, 319, 371, 450, 504
Woessner, Kathryn, 288
Wojciechowski, Christopher, 246
Wolf, Rachel, 487, 489
Wong, Joseph, 539
Wong, Nicole, 119, 270, 399
Wong, Sissy, 296
Woo, E., 113, 200
Woodson, Ashley, 385
Worsley, Ti'Era, 228, 411
Wright, Chris, 80, 219
Wright, Diane, 387
Wright, Gary, 33
Wright, Tanya, 518
Wu, Ce, 334
Wu, Hsin-Kai, 473
Wu, Linfeng, 359
Wulff, Peter, 42, 222
Wusylko, Christine, 330
Wyrwich, Tobias, 82
Xia, Xin, 223, 272, 406
Xiang, Lin, 302, 367
Xie, Yong, 448
Xin, Yue, 24
Xu, Shiyu, 324
Xu, Shuang, 86
Xu, Zhen, 129, 215, 277, 307, 366, 480
Xue, Mingfeng, 355
Yadav, Aman, 169
Yan, Lin, 24
Yan, Shulong, 424
Yang, Jhu-Chun, 193

Yang, Jie, 58, 73
Yang, Shuhao, 448
Yang, Sohheon, 284
Yao, Jianxin, 242
Yarden, Anat, 331
Yayon, Malka, 292
Yeasmin, Sonia, 280
Yeldell, Jasmyne, 446
Yemini, Miri, 75
Yerushalmi, Edit, 144
Yesilyurt, Ezgi, 157, 191
Yilmaz-Tuzun, Ozgul, 18
Yin, Xinying, 493
Yin, Yue, 520
Ying, Kaitlyn, 331
Yılmaz-Tüzün, Özgül, 84
Yoel, Shahaf, 13
Yonai, Ella, 60, 177, 179, 180, 405, 429, 519
You, Hyesun, 244, 262
Young, Kirsty, 488
Yow, Jan, 314
Yu, Linyu, 83
Yue, Lei, 250
Yun, Minji, 102, 411
Zahran, William, 77
Zaidi, Sania, 385, 440
Zaluzhna, Maryna, 187
Zandvliet, David, 34, 339
Zangori, Laura, 129, 277, 366, 419
Zazueta, Alex, 402
Zecher, Tina, 532
Zeidler, Dana, 34, 84, 338, 428, 448
Zembal-Saul, Carla, 209
Zeng, Litong, 14
Zeng, Mao-Ren, 46, 216, 473
Zhai, Xiaoming, 71, 289, 326, 337, 414
Zhang, Helen, 313, 326, 346
Zhang, Liwei, 390, 534
Zhang, Man, 236
Zhang, Ren-Cheng, 473
Zhang, Yang, 1, 168, 536
Zhang, Yingzhi, 26
Zhang, Zhongyan, 452
Zhao, FangFang, 58
Zheng, Yonghe, 448
Zheng, Zhuang, 334
Zhong, Qiu, 49
Zhu, Li, 263
Ziegler, Hannah, 390, 496, 534
Zietowski, Jenna, 13
Zipperer, Jill, 523
Zogheib, Khadija, 542
Zouda, Majd, 8, 25
Zucker, Andy, 181
Zuercher, Jennifer, 349
Zugic, Jessica, 210
Zuiker, Steve, 294
Zulawski, Jessica, 251
Zulli, Rebecca, 373
Zummo, Lynne, 139
Zwick, Melissa, 373
Zwiep, Susan, 490