96th NARST International Conference | Program

April 18 - 21, 2023

REFLECTING on REFORM

Coming together to reflect on global science education reforms

Chicago, Illinois – Hilton Downtown Chicago

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96th 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.

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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: http://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.

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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: **Angela Chapman**, University of Texas Rio Grande Valley
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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: **Francesca Williamson**, Indiana University
frawhite@iu.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: **Monica Cardella**, Florida International University
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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.

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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.

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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.

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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**

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Sherry Southerland
Shiang-Yao Liu
Shirly Avargil
Shukufe Rahman
Sierra Morandi
Silvia Jessica Mostacedo Marasovic
Soon Lee
Soonhye Park
Sophia Jeong
Stefan Sorge
Stefanie Marshall
Stephen Burgin
Stephen Thompson
Stephen Witzig
SuChi Fang
Sugat Dabholkar
Suzanne Poole
Swarna Mahapatra
T Sikorski
T.S. Yang
Taiwo Ogundapo
Takeshia Pierre
Takunda Maisva
Takuya Matsuura
Tamar Fuhrmann
Tamar Ginzburg
Tania Jarosewich
Ted Clark
Teresa Leavens
Teresa Massey
Terrance Burgess
Tess Bernhard
Tessa Andrews
Theila Smith
Thomas McKenna
Ti'Era Worsley
Tim Goebel
Tim Hartelt
Tingting Li
Todd Harwell
Toma Radu Bogdan
Tulana Ariyaratne
Tyler Harper-Gampp
Valarie Akerson
Vanessa Fischer
Vanessa Louis
Verena Ruf
Veronica McGowan
Veronika Rozhenkova
William Romine
Wisal Ganaiem
Wisam Sedawi
Won Jung Kim
Wonyong Park
Xinyu He
Yael Rozenblum
Yang Zhanng
Yehudit Judy Dori
Yejun Bae
Ying Chen
Ying-Yan Lu
Yu Zhang
Yu-Chen Chiu
Yu-Jan Tseng
Zac Patterson
Zoubeida Dagher

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**

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

Alan McCormack
Albert Nous
Avi Hofstein
Aviva Klieger
Barbara Crawford
Bill Jaffarian
Carl Angell
Charles Anderson
Charles McFadden
Dale Baker
David Haury
David Kennedy
Donald Riechard
Donald Schmidt
Doris Ash
Doris Simonis
Ed Van Den Berg
Edward Smith
Eileen Parsons
Elke Sumfleth
Ellen Simmons
Elsa Feher
George Bodner
Gerald Krockover
Gian Pedemonte
Glenn Berkheimer
Glenn Markle
Gottfried Merzyn
Guilford Bartlett
Hanna Arzi
Hans Andersen
Helmut Dahncke
Herbert Thier
Ivo Lindauer
J. Prather
J. Swift
Jacqueline Mallinson
James Poth
James Shymansky
Jane Kahle
Jay Lemke
Jim Minstrell
John Christopher
Joseph Novak
Judith Lederman
Julia Clark
Kathryn Scantlebury
Larry Enochs
Larry Yore
Leonie Rennie
Linda Phillips
Lowell Bethel
Mansoor Niaz
Manuel Sequeira
Marianne Barnes
Marlene Thier
Michael Agin
Michael Padilla
Michael Piburn
Nitza Barnea
Obed Norman
Onno De Jong
Patricia Friedrichsen
Paul Joslin
Peter Hewson
Peter Okebukola
Richard Haney
Richard Walding
Robert Dehaan
Robert Poel
Robert Sherwood
Robert Williams
Rodney Doran
Roger Olstad
Ronald Anderson
Ryda Rose
Stanley Helgeson
Sue Tunnicliffe
Sung Jae Pak
Uri Ganiel
Vincent Lunetta
Wayne Welch
William Holliday

NARST Award Recipients

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

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

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**

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**

Future NARST Meeting Dates

2024
March 16–19 | Denver, CO

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

2026
April 18-21 | Seattle, WA

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 Leadership Committees

Elections Committee

Final Year	Committee Leadership
2023	**Nazan U. Bautista** (Chair) Miami University
2025	**David Crowther** (Co-Chair) University of Nevada, Reno
	Members
2024	**Hernán Cofré Mardones** Pontificia Universidad Católica de Valparaíso, Chile
2024	**Miri Barak** Technion
2024	**Holly Kennedy Amerman** University of Georgia
2025	**Carina Rebello** Purdue University
	Board Member Liaison
2024	**Scott McDonald** Penn State University
	Representative from the International Committee
2023	**Sheron Mark** University of Louisville
	Ex Officio
2023	**Renee Schwartz** (Immediate Past President) Georgia State University

Equity and Ethics Committee

Final Year	Committee Leadership
2023	**María González-Howard** (Chair) University of Texas, Austin
	Members
2023	**Sara Salloum** University of Balamand
2024	**Ebru Eren** Trinity College of Dublin, Ireland
2024	**Erdogan Kaya** George Mason University
2024	**Phillip Boda** University of California, Berkeley
2024	**David Steele** Alder Graduate School of Education
2025	**Marsha E Simon** University of West Georgia
2025	**Justice T. Walker** University of Texas, El Paso
2025	**Regina McCurdy** Georgia Southern 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
	Members
2023	**Henriette Burns** Southern Illinois University, Edwardsville
2023	**Peter Okebukola** Lagos State University, Nigeria
2024	**Xavier Fazio** Brock University, Canada
2024	**Francesca Williamson** Butler University
2024	**Andy Cavagnetto** Washington State University
2025	**Sara Raven** Texas A&M University
2025	**Ellen Granger** Florida State University
	Board Liaison
2024	**Leon Walls** University of Vermont
	Ex Officio Members
2023	**Gillian Roehrig** (President) University of Minnesota
	Lisa Martin-Hansen (Executive Director)

NARST Leadership Committees

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	Committee Leadership
2023	**Theila Smith** (Chair) University of Groningen
2023	**Scott Cohen** (Co-Chair) Georgia State University
	Members
2023	**Sandhya Krishnan** University of Georgia
2023	**Andrea Reeder** Middle Tennessee State University
2023	**Uchechi Agnes Ahanonye** University of the Witwatersrand, Johannesburg
2023	**Jennifer Slavick** West Chester University
2023	**Helena Aptyka** Institute for Biology Education, Germany
2023	**Samantha Ringl** University of Kentucky
2024	**Jared TenBrink** University of Michigan, Ann Arbor
2024	**Justin Andersson** University of Nebraska, Lincoln
2024	**Sabrina Stanley** University of Alabama
2024	**Zhongyan Zhang** University of Leeds
2024	**Ti'Era Worsley** University of North Carolina, Greensboro
	Ex Officio Member
2025	**Jomo Mutegi** (President-Elect) Old Dominion University

Awards Committee

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

Outstanding Doctoral Research Award

Final Year	Committee Leadership
2023	**Heidi Cian** (Chair) Florida International University
2024	**Julia Plummer** (Co-Chair) Penn State University
	Members
2023	**Juan F Diaz** MAC US
2023	**Terrance Burgess** Michigan State University
2023	**Eve Manz** Boston University
2023	**Jianlan Wang** Texas Tech University
2024	**Judith Lederman** Illinois Institute of Technology
2024	**Jayma Koval** Georgia State University
2024	**Michael Zion** Bar Ilan University, Israel
2024	**Mary E. Short** George Washington University
2025	**Guopeng Fu** East China Normal University
2025	**Eunjin Bahng** Iowa State University
2025	**Nilay Ozturk** Kirsehir Ahi Evran University
2025	**David C. Owens** Georgia Southern University
2025	**Maia Elkana** Washington University, St. Louis

NARST Leadership Committees

Awards Committee (con't)

Early Career Research Award	
Final Year	**Committee Leadership**
2023	**Hsin-Kai Wu** (Chair) National Taiwan Normal University
2024	**Doug Larkin** (Co-Chair) Montclair State University
	Members
2023	**Matthew Weinstein** University of Washington, Tacoma
2023	**Doris Ash** University of California, Santa Cruz
2023	**Anton Puvirajah** University of Western Ontario
2024	**Eleanor Abrahms** University of Massachusetts, Lowell
2025	**Ben Herman** Texas A&M University
2025	**Christine Lotter** University of South Carolina
2025	**Meg Blanchard** North Carolina State University
2025	**Erin Peters-Burton** George Mason University
2025	**Bridget Miller** University of South Carolina
2025	**Larry Yore** University of Victoria

Distinguished Contributions to Science Education Through Research	
Final Year	**Committee Leadership**
2024	**Dana Neidler** (Chair) University of South Florida
2024	**Xiufeng Liu** (Co-Chair) University of Buffalo
	Members
2023	**Agustín Adúriz-Bravo** Universidad de Buenos Aires
2023	**Dale Baker** Arizona State University
2023	**Fouad Abd-El-Khalic** University of North Carolina, Chapel Hill
2024	**Valarie Akerson** Indiana University
2025	**Justin Dillon** Exeter University, UK
2025	**Kathy Trundle** Utah State University
2025	**Mei-Hung Chiu** National Taiwan Normal University

NARST Fellows Award	
Final Year	**Committee Leadership**
2024	**Hosun Kang** (Chair) University of California, Irvine
2024	**Lama Jaber** (Co-Chair) Florida State University
	Members
2023	**Lucy Avraamidou** University of Groningen
2024	**Julie Luft** University of Georgia
2025	**Senay Purzer** Purdue University
2025	**Enrique Suarez** University of Massachusetts, Amherst
2025	**Lezly Taylor** Virginia Polytechnic Institute and State University

NARST Leadership Committees

International Committee

Final Year	International Coordinator
2025	**Mercy Ogunsola-Bandele** (Chair) National Open University of Nigeria
	Committee Leadership
2023	**Gavin Fulmer** (Chair) University of Iowa
2024	**Hayat Hokayem** (Co-Chair) Texas Christian University
	Members
2023	**Sheron Mark** University of Louisville
2023	**Tasneem Anwar** Aga Khan University
2024	**Claudia Vergara** Alberto Hurtado University, Chile
2024	**Irene Drymiotou** University of Cyprus and University of Groningen
2024	**Stefan Sorge** IPN Leibniz Institute for Science and Mathematics Education, Germany
2024	**Lucía Vázquez Ben** Universidad da Coruña, Spain
2024	**Lee Kenneth Jones** Texas Tech University
2025	**Imran Tufail** University of Waikato
2025	**Ranu Roy** Amity University Kolkata
2025	**Aerin W. Benavides** University of North Carolina, Greensboro
2025	**Nuri Balta** Suleyman Demirel University

Membership Committee

Final Year	Committee Leadership
2023	**Elizabeth de los Santos** (Chair) University of Nevada, Reno
2025	**Mihwa Park** (Co-Chair) Texas Tech University
	Members
2023	**K.C. Busch** North Carolina State University
2024	**Tugba Yuksel** Recep Tayyip Erdogan University
2024	**Shiang-Yao Liu** National Taiwan Normal University
2024	**Robert Bennett** Georgia State University
2025	**Melanie Kinskey** Sam Houston State University
2025	**Harini Krishnan** Florida State University
2025	**Harleen Singh** University of Georgia
	Board Liaison
2023	**Brooke Whitworth** Clemson University

NARST Leadership Committees

Program Committee	
Final Year	**Leaders**
2023	**Gillian Roehrig, President** (Chair) University of Minnesota
2024	**Jomo Mutegi** (President-Elect) Old Dominion University
	Ex Officio Member
	Lisa Martin-Hansen (Executive Director)
	Members
2023	**Shannon Navy** Kent State University
2023	**Angela Chapman** University Of Texas, Rio Grande Valley
2023	**Selina Bartels** Valparaiso University
2023	**Jose Pavez** University of Georgia
2023	**Grant Gardner** Middle Tennessee State University
2023	**Eli Tucker-Raymond** Boston University
2023	**Amanda Berry** Monash University, Australia
2023	**Patrick Enderle** Georgia State University
2023	**Jing Lin** Beijing Normal University
2023	**Katharine Wade-Jaimes** University of Nevada
2023	**Preethi Titu** Kennesaw State University
2023	**Gunkut Mesci** Giresun University, Turkey
2023	**Heather Page** New York City Department of Education
2023	**Sanlyn Buxner** University of Arizona
2024	**Xiaoming Zhai** University of Georgia
2024	**Patricia Patrick** Columbus State University
2024	**Karl Jung** University of South Florida
2024	**Elizabeth Lewis** University of Nebraska, Lincoln
2024	**Anita Schuchardt** University of Minnesota
2024	**Neta Shaby** Ben Gurion University of the Negev
2024	**Amal Ibourk** Florida State University
2024	**Julie Bianchini** University of California, Santa Barbara
2024	**Tejaswini Dalvi** Univerity of Massachusetts, Boston
2024	**Kathryn Kirchgasler** University of Wisconsin, Madison
2024	**Richard Lamb** East Carolina University
2024	**Jacob Pleasants** Oklahoma University
2024	**Wardell A. Powell** Framingham State University
2024	**Felicia Leammukda** St. Cloud State University

NARST Leadership Committees

Publications Advisory Committee

Final Year	Committee Leadership
2023	**Dante Cisterna** (Chair) Education Testing Service
2024	**Lindsay Lightner** (Co-Chair) Washington State University Tri-Cities
	Members
2023	**Fouad Abd-El-Khalick** University of North Carolina
2023	**Shakhnoza Kayumova** University of Massachusetts, Dartmouth
2024	**Emily Dare** Florida International University
2024	**Saouma BouJaoude** American University of Beirut, Lebanon
2024	**Carla Johnson** North Carolina State University
2024	**Kent Crippen** University of Florida
2025	**Cesar Delgado** North Carolina State University
2025	**Tina Vo** University of Nevada, Las Vegas
2025	**Li Ke** University of North Carolina, Chapel Hill
2025	**Linda Morell** UC Berkeley
	Board Liaison
2023	**Knut Neumann** Leibniz Institute for Science and Mathematics Education
	Ex Officio Members
2025	**Troy Sadler** (*JRST* Editor) University of North Carolina, Chapel Hill
2025	**Felicia Moore Mensah** (*JRST* Editor) Teachers College, Columbia University
2024	**Gillian Roehrig** (President) University of Minnesota
2024	**Cynthia Crockett** NSTA Research Division Director Harvard University
	Lisa Martin-Hansen (Executive Director)

Research Committee

Final Year	Committee Leadership
2023	**Rouhollah Aghasaleh** (Chair) Humboldt State University
2024	**Sarah Fick** (Co-Chair) Washington State University
	Members
2023	**Lori Andersen** University of Kansas
2023	**Narendra Deshmukh** Tata Institution of Fundamental Research
2023	**Sissy Wong** University of Houston
2024	**Natalie King** Georgia State University
2024	**Jessica Karch** University of Massachusetts, Boston
2024	**Peter Wulff** University of Potsdam, Germany
2024	**Mwenda O Kudumu** North Carolina State University
2025	**James Nyachwaya** North Dakota State University
2025	**Bryan H. Nichols** Florida Atlantic University
2025	**Ezgi Yesilyurt** Weber State University
2025	**Mina Sedaghatjou** Alfred University
2025	**Karen Woodruff** Montclair State University
2025	**Liam Guilfoyle** University of Oxford
	Board Liaison
2024	**Malcolm Butler** University of North Carolina, Charlotte
	NARST Liaison to NSTA
2024	**Michael Bowen** Mount Saint Vincent University

NARST Leadership Committees

Social Media, Website and Communications Committee	
Final Year	**Committee Leadership**
2023	**Len Annetta** (Chair) East Carolina University
2025	**Ryan Cain** (Co-Chair) Weber State University
	Members
2023	**Jaclyn Murray** Augusta University
2023	**Amber Adgerson** University of South Carolina
2024	**Stephanie Teeter** North Carolina State University
2024	**Stanton Belford** University of Tennessee Southern
2024	**Mark Newton** East Carolina University
2024	**Amy Voss Farris** Penn State University
2025	**Anna Maria Arias** Kennesaw State University
2025	**Sarah Frodsham** Oxford Brookes University
2025	**Won Jung Kim** Santa Clara University
	Board Liaison
2023	**Christina Schwarz** Michigan 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

Gillian Roehrig

Christina Schwarz

Jennifer Slavick

Brooke Whitworth

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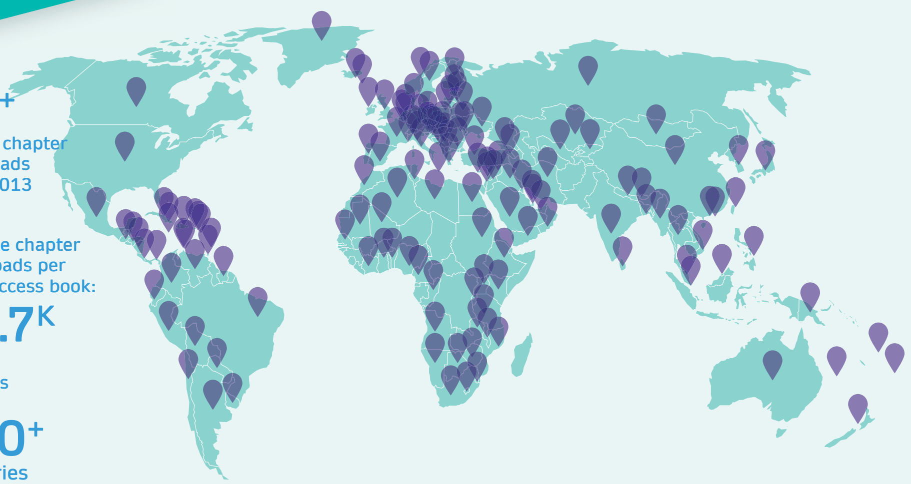

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NARST 2024 Conference Theme

Prepared by Jomo W. Mutegi

Science Education for the Rest of Us

William Lutz, in his book *Doublespeak*, describes the various ways that governments and corporations present alternative truths and misrepresent reality. In one of his lectures on the book, Lutz used sugar labeling as an example of doublespeak. After the lecture an audience member explained that he had been diagnosed with diabetes some years prior. The audience member further explained that he and his wife were religious about reading food labels and avoiding food products with added sugar. He then grew solemn as he thanked Lutz and admitted that, "I just learned today that for years I've been eating 'sugar-free' products that actually contain sugar."

This audience member is not alone. A 2017 study in the journal *Preventing Chronic Disease* found that many consumers (anywhere from 25-50%) have difficulty understanding and making decisions based on nutrition labels. Neither is this audience member alone in his struggle against diabetes. In 2012, the CDC estimated that one in every 7 to 8 adults had Type II Diabetes. And this number is growing rapidly. Between 1990 and 2010, the number of people with diabetes tripled.

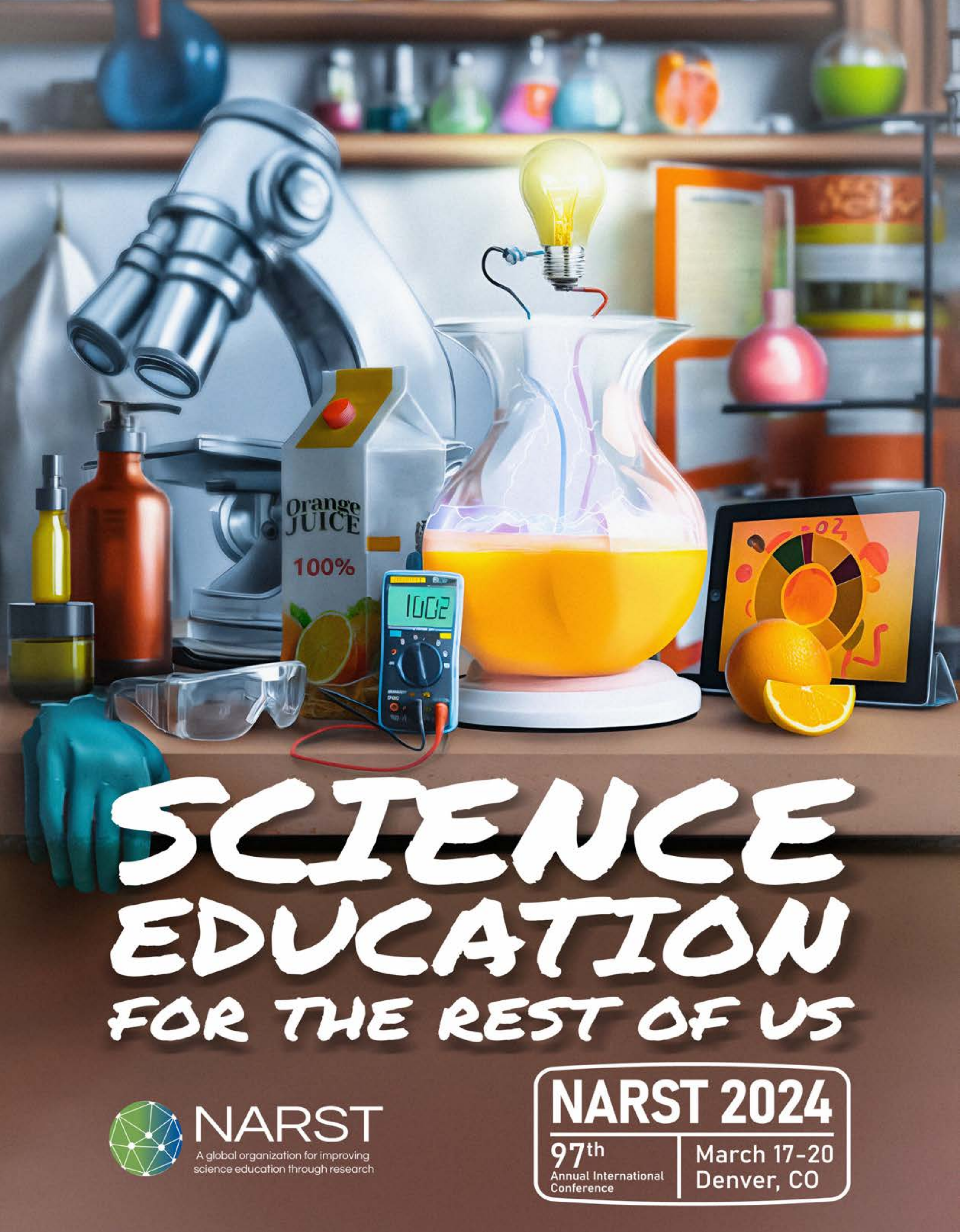
Diabetes is not the only threat. Lead tainted water, adulterated food, perfluoroalkyl substances, addictive devices, corporate and governmental disinformation, and adverse cultural agendas are among hundreds of threats that accompany STEM advances. Although children spend most of their waking hours in school, studies on public understanding of science consistently show that they are not becoming adults who are able to recognize, understand and successfully navigate these threats. While the threats that result from STEM advances are not caused by STEM educators (and those with a vested interest in STEM education), we may unknowingly be complicit in maintaining them.

One of our biggest challenges may be our longstanding effort to use K-12 science education as a space for producing more scientists. The goal of producing more scientists has been explicitly articulated in every major reform movement from *Sputnik to Science for All Americans*, to the *National Science Education Standards*, to the *Next Generation Science Standards*.

The effort to produce more scientists would not be a problem except that the percentage of scientists is very small. In its Science Report, Towards 2030, the United Nations Educational, Scientific, Cultural Organization (UNESCO) reports that there are 7.8 million full-time science researchers worldwide. While this number may seem large it represents only 0.1% of the world's population. So we are essentially teaching a version of science to all children that amounts to career preparation for 0.1% of the world. At the same time, the rest of us (99.9%) are not gaining an understanding of science that would enable us to enrich our lives.

The conference theme, ***Science Education for the Rest of Us***, is intended to foreground the purpose of science education, and to draw our collective attention to the many socio-scientific issues that are increasingly important in modern society but have yet to find a place in the standard K-12 curriculum. There is no better place to engage in this exciting work than with colleagues at the 2024 NARST Annual Conference.

We welcome your contributions and look forward to seeing you in Denver!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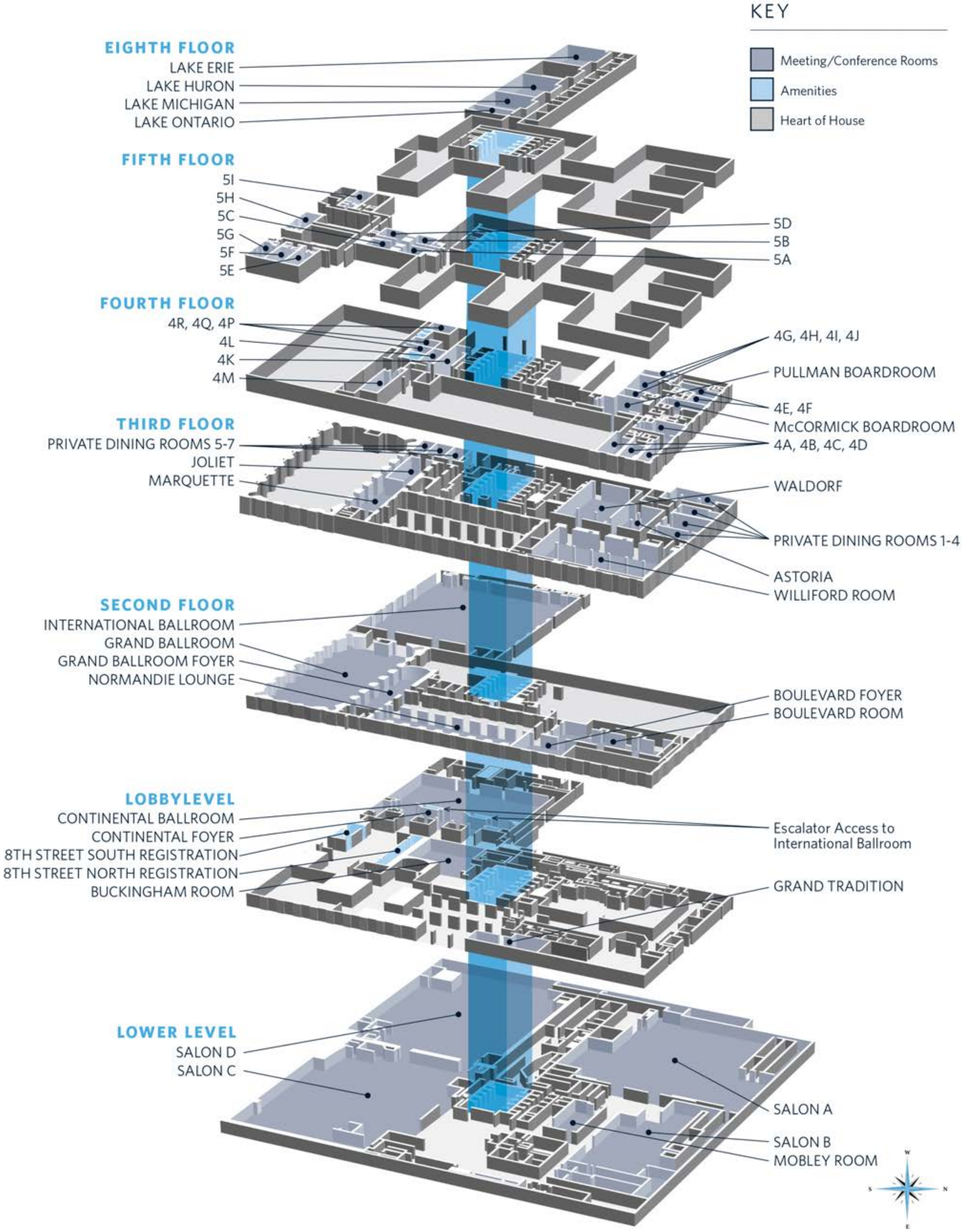

NARST 2023 International Conference
Schedule at a Glance

All times are USA Central Time

Regular Sessions	*Workshops*	*Business Meetings*	*Social Events*
Date/Time	**Event**		**Room**
Monday, April 17			
3:00 pm – 5:00 pm	Registration		8th St. Foyer on Lobby Level [near Business Center]
8:00 am – 5:00 pm	NARST Board Meeting		Waldorf
Tuesday, April 18			
Pre-Conference Events			
7:30 am – 7:00 pm	Registration		2nd floor landing
8:00 am – 12:00 pm	NARST Board Meeting		Waldorf
8:00 am – 9:00 am	Mentor-Mentee Nexus (ticketed event) Sponsor: Membership Committee		Salon A5
9:10 am – 10:10 am	Early Career Faculty Forum (ticketed event) Sponsor: Membership Committee		Salon A5
10:20 am – 11:20 am	Welcome Session (ticketed event) Sponsor: Membership Committee		Salon A5
Pre-Conference Workshops			
8:00 am – 11:45 am	Integrating Science with Computer Science for Linguistically Diverse Classrooms at Upper Elementary Grades via Educational Robotics Sponsor: Research Committee		Salon A1
8:00 am – 11:45 am	Use of cutting-edge technologies in STEM education. Programs and lessons learned with AR, VR, and 3D modeling Sponsor: Research Committee		Salon A2
8:00 am – 11:45 am	Critically theorizing the margins for reform-based equity in science: A disobedient reckoning Sponsor: Equity and Ethics Committee		Salon A3

8:00 am – 11:45 am	Towards Scientific Literacy in Inclusive Science Education – A New Approach to Support Pre- and In-Service Teachers Sponsor: Research Committee	Salon A4
8:00 am – 11:45 am	Observing Integrated STEM Education in K-12 Science and Engineering Classrooms with New Tools and Resources Sponsor: Research Committee	Salon C1-2
8:00 am – 11:45 am	Assessing Early Childhood and Primary Students' Views of Science: Learning to Administer and Score two Valid and Reliable Instruments (Views about Scientific Inquiry- Elementary and Young Children's Views about Science) Sponsor: Research Committee	Salon C3-4
8:00 am – 11:45 am	Dismantling Systemic Inequalities in Indigenous STEM Education Sponsor: ISK-RIG	Spencer Foundation, 625 N Michigan Ave
11:45 am – 1:00 pm	Graduate Student Luncheon [ticketed event]	Salon A5
11:45 am – 1:00 pm	Lunch break	
	Conference Begins	
1:00 pm – 1:30 pm	Presidential Welcome: Gillian Roehrig, NARST President	Grand Ballroom
1:30 pm – 2:45 pm	Keynote Address: Dr. Christine Cunningham, Pennsylvania State University *Engineering Science Reform*	Grand Ballroom
3:00 pm – 4:30 pm	Concurrent Session #1	See Program
4:45 pm – 6:15 pm	Concurrent Session #2	See Program
7:00 pm – 8:30 pm	Presidential Reception and Welcome Celebration (appetizers and cash bar)	Grand Ballroom

Wednesday, April 19		
6:00 am – 8:00 am	Mind and Sole Fun Run (off-site) *Not sponsored by NARST*	Meet in Conference Hotel Lobby
7:30 am – 4:30 pm	Registration	2nd floor landing
7:00 am – 8:00 am	RIG Business Meetings [continental breakfast provided beginning at 6:30 am]	Salon A Foyer
	Asian and Pacific Islander Science Education Research [APISER]	Salon A1
	Latino/a RIG [LARIG]	Salon A2
	Contemporary Methods for Science Education Research	Salon A3
	Engineering Education [ENE-RIG]	Salon A4
	Indigenous Science Knowledge [ISK-RIG]	Salon A5
	Research in Artificial Intelligence-involved Science Education [RAISE]	Salon C1-2
	Continental and Diasporic Africa in Science Education RIG (CADASE)	Salon C3-4
8:25 am – 9:55 am	Concurrent Session #3 (includes Roundtables #1)	See Program
9:55am – 10:20am	Coffee break	Salon A Foyer and Normandie Room (2nd Floor)
10:20 am – 11:50 am	Concurrent Session #4	See Program
11:50 pm – 1:00 pm	Lunch break	
1:00 pm – 2:30 pm	Concurrent Session #5	See Program
2:45 pm – 4:15 pm	Awards Dessert Reception (Coffee and dessert provided)	Grand Ballroom
4:30 pm – 6:00 pm	Concurrent Session #6	See Program
6:30 pm – 7:30 pm	Graduate Student Forum	Salon A5
6:30 pm – 7:30 pm	JRST Dinner (by invitation)	Astoria

Thursday, April 20		
7:30 am – 4:30 pm	Registration	2nd floor landing
7:30 am – 8:30 am	Committee Meetings [continental breakfast provided beginning at 7:15 am]	Salon A Foyer
	Elections	Salon A2
	Awards	Salon A3
	Research	Salon A4
	Equity and Ethics	Salon C1-2
	External Policy and Relations	Salon C3-4
	International	Salon C5-6
	Graduate Students	Salon C7-8
	Membership	Salon A1
	Publications Advisory	Salon A5
	Social Media, Website, Communications	Blvd A
	Program [strand coordinators]	Blvd C
8:40 am – 10:10 am	Concurrent Session #7	See Program
10:30 am – 12:00 pm	Concurrent Session #8 (Includes Roundtables #2)	See Program
12:00 pm – 1:10 pm	Lunch break	
1:10 pm – 2:40 pm	Concurrent Session #9	See Program
2:50 pm – 3:35 pm	Poster Session A (coffee and snacks provided)	Grand Ballroom
3:35 pm – 4:20 pm	Poster Session B (coffee and snacks provided)	Grand Ballroom
4:30 pm – 6:00 pm	Concurrent Session #10	See Program
6:10 pm – 9:00 pm	Equity and Ethics Dinner (registration and prepay required)	Off-site

Friday, April 21		
8:00 am -12:00 pm	Registration	2nd floor landing
8:00 am – 8:50 am	Membership and Business Meeting Meet Board of Directors [continental breakfast provided beginning at 7:30 am]	Salon A1
9:00 am – 10:30 am	Concurrent Session #11	See Program
10:45 am – 12:15 am	Concurrent Session #12 (Includes Roundtables #3)	See Program
12:15 pm – 1:45 pm	Lunch break	
1:45 pm – 3:15 pm	Concurrent Session #13	See Program
3:15 pm – 4:15 pm	CLOSING SESSION Looking ahead to the 2024 Conference Showing appreciation for Board and Committee leadership.	Salon A1
5:00 pm – 10:00 pm	NARST Board meeting	Off-site

Note: The Normandie Room on the 2nd Floor is available to use all week as a break room and workspace.

Friday, April 28	**All-Virtual Conference Day**	
7:00 am – 7:30 am	Welcome from President Gill Roehrig and Conference Overview	Zoom A
7:45 am – 8:45 am	Concurrent Session #1	Zoom A and B
8:45 am – 9:15 am	Breakout Discussions	Multiple breakout rooms
9:30 am – 10:30 am	Concurrent Session #2	Zoom A and B
10:45 am – 12:00 pm	Concurrent Session #3	Zoom A and B
12:15 pm – 1:00 pm	Poster Session	Poster Gallery
1:00 pm – 2:00 pm	Lunch break	
2:00 pm – 3:00 pm	Concurrent Session #4	Zoom A and B
3:15 pm – 4:15 pm	Concurrent Session #5	Zoom A and B
4:15 pm – 4:40 pm	Breakout Discussions	Multiple breakout rooms
4:40 pm – 5:00 pm	Closing Session Remarks from outgoing President Gill Roehrig and incoming President Jomo Mutegi	Zoom A

Pre-Conference Workshops

Research Committee
Pre-Conference Workshop: Integrating Science with Computer Science for Linguistically Diverse Classrooms at Upper Elementary Grades via Educational Robotics
4/18/23, 8:00-11:45, Salon A1 (LL)

Integrating Science with Computer Science for Linguistically Diverse Classrooms at Upper Elementary Grades via Educational Robotics

ORGANIZERS
Erdogan Kaya, George Mason University, USA
Ezgi Yesilyurt, Weber State University, USA
Refika Turgut, University of South Carolina Upstate, SC, USA
Burak Sahin, University of Nevada, Las Vegas, NV, USA
Hasan Deniz, University of Nevada, Las Vegas, NV, USA

ABSTRACT
This workshop will engage participants in how to integrate computer science concepts and practices with rich science and literacy connections at the upper elementary grades. Participants will be able to develop skills to address the Next Generation Science Standards, CSTA Computer Science Education Standards and Literacy Standards while considering the needs of multilingual learners (MLs).

Research Committee
Pre-Conference Workshop: Use of cutting-edge technologies in STEM education. Programs and lessons learned with AR, VR, and 3D modeling
4/18/23, 8:00-11:45, Salon A2 (LL)

Use of cutting-edge technologies in STEM education. Programs and lessons learned with AR, VR, and 3D modeling

ORGANIZERS
Sandra Arango-Caro, Donald Danforth Plant Science Center, USA
Kristine Callis-Duehl, Donald Danforth Plant Science Center, USA

ABSTRACT
The application and innovation of technology are essential components of the transformative change that education is currently experiencing. Emergent technologies and practices are playing a key role in improving student access to content and enriching experiences in science, technology, engineering, art, and math (STEAM), contributing to student interests and

motivation in STEAM fields and careers. This access is of particular importance for underserved and rural schools with limited resources to science research facilities and scientific laboratories. Likewise, students with disabilities have limitations to firsthand and hands-on science experiences that technology can help to overcome.
The Education Research & Outreach Lab (EROL) at the Donald Danforth Plant Science Center offers students learning experiences that foster engagement in science practice, collaboration, and communication bringing plant and agricultural sciences to the classroom. The EROL Education Technology program offers educational experiences using augmented and virtual reality (AVR), 3D modeling, computer gaming, and geospatial tools (https://www.danforthcenter.org/our-work/education-outreach/education-technology-program/). Workshop participants will be introduced to this program and its lessons learned, to motivate educators to integrate technologies in their classrooms and facilitate access to resources that otherwise can be limited for science learning and interest in STEM fields.

Equity And Ethics Committee
Pre-Conference Workshop: Critically theorizing the margins for reform-based equity in science: A disobedient reckoning
4/18/23, 8:00-11:45, Salon A3 (LL)

Critically theorizing the margins for reform-based equity in science: A disobedient reckoning

ORGANIZERS
Philip Boda, University of Illinois, Chicago, IL, USA
Justice Walker, The University of Texas, El Paso, TX, USA
Gary Wright, North Carolina State University, NC, USA

ABSTRACT
Centering Lives relegated to the margins in mainstream science education research, practice, and policy is crucial for equitable reform. Students labeled with disabilities are still not integrated in social justice theorizing and design. Additionally, despite calls to advance gender and sexual diversity among equitable reform goals, the field has yet to adopt more contemporary paradigms, privileging cis-gender and heterosexual identities as the unquestioned majority. Given the reality that the status quo of science education policy is designed as a majority-won interest in academic achievement, we ask: What can Disabled and LGBTQ perspectives bring to the critical work in science education reform-based equity? Defying what has been built before us in the field as the most important conceptual links to drive equity-based reform, we argue that to disobey this persistence in valorizing cis-abled-bodied heterosexual perspectives over those outside that center becomes a radical step to redraw philosophical, methodological, and epistemological boundaries. We therefore stake the claim that using this workshop as a session to think beyond “what is” and engage “what if” can become a generative space to theorize among these margins, and Dream disobediently.

Research Committee
Pre-Conference Workshop: Towards Scientific Literacy in Inclusive Science Education - A New Approach to Support Pre- and In-Service Teachers
4/18/23, 8:00-11:45, Salon A4 (LL)

Towards Scientific Literacy in Inclusive Science Education - A New Approach to Support Pre- and In-Service Teachers

ORGANIZERS
Lisa Stinken-Rösner, Leuphana University, Lueneburg, Germany
Stefanie Lenzer, Leibniz University, Hannover, Germany
Laura Sührig, Goethe University, Frankfurt, Germany
Andreas Nehring, Leibniz University, Hannover, Germany
Simone Abels, Leuphana University, Lueneburg, Germany

ABSTRACT
Scientific literacy as a central goal of modern science education has to be accessible for every student, regardless of their background. Teachers face the challenge of meeting demands of science education while welcoming the diversity of students to address inclusion and equity in their teaching. However, they are often hindered by existing systems to develop the necessary competencies.
Implementing inclusive science teaching in classroom practice still remains challenging. Hence, additional resources are needed to support pre- and in-service science teachers in planning and reflecting on lessons that acknowledge students" diversity, recognize possible barriers, and enable participation for all.
Members of the Network for Inclusive Science Education (NinU) collaboratively created a framework-based approach to fill this gap in which the perspectives of science education and inclusive pedagogy are combined to provide a resource for supporting in-service science teachers in planning and reflecting on inclusive science lessons. The NinU framework has been implemented in several teacher education programs and has shown to be a valuable resource to raise pre-service science teachers" understanding of diversity and equity. Workshop participants will learn about the theory behind the NinU framework and reflect on how the framework can be used at school and university level.

Research Committee
Pre-Conference Workshop: Observing Integrated STEM Education in K-12 Science and Engineering Classrooms with New Tools and Resources
4/18/23, 8:00-11:45, Salon C1-2 (LL)

Pre-Conference Events, 4/18/23, 08:00-11:45

Observing Integrated STEM Education in K-12 Science and Engineering Classrooms with New Tools and Resources

ORGANIZERS
Emily Dare, Florida International University, FL, USA
Joshua Ellis, Florida International University, FL, USA
Elizabeth Ring-Whelan, St. Catherine University, USA
Gillian Roehrig, University of Minnesota - Twin Cities, MN, USA
Mark Rouleau, Michigan Technological University, MI, USA
Benny Hiwatig, University of Minnesota – Twin Cities, MN, USA
Farah Faruqi, University of Minnesota – Twin Cities, MN, USA
Christopher Irwin, Florida International University, FL, USA

ABSTRACT
This workshop will engage participants from the science teacher education and the science and STEM education research communities in learning about the STEM Observation Protocol (STEM-OP) - a new 10-item protocol designed for observing integrated STEM lessons within K-12 science and engineering classrooms. Participants will be provided with opportunities to learn about our conceptual framework for integrated STEM education and the development of the protocol along with reliability measures. The focus of the workshop will be dedicated to practice using the protocol with example classroom video of integrated STEM lessons. This workshop will also introduce the associated training platform designed to support new users of the protocol. The training platform utilizes the popular Learning Management System Canvas to guide new users through a series of modules to educate them about the protocol"s 10 items. The modules include opportunities for users to practice using the instrument and receive immediate feedback to facilitate learning. Multiple uses of the protocol and the training platform, including for science teacher education and educational research, will be discussed.

Research Committee
Pre-Conference Workshop: Assessing Early Childhood and Primary Students' Views of Science: Learning to Administer and Score two Valid and Reliable Instruments (Views about Scientific Inquiry- Elementary and Young Children's Views about Science)
4/18/23, 8:00-11:45, Salon C3-4 (LL)

Assessing Early Childhood and Primary Students' Views of Science: Learning to Administer and Score two Valid and Reliable Instruments (Views about Scientific Inquiry- Elementary and Young Childrens' Views about Science)

ORGANIZERS
Judith Lederman, Illinois Institute of Technology, IL, USA
Selina Bartels, Valparaiso University, IN, USA

ABSTRACT
Helping students, teachers and pre-service teachers develop informed views about scientific inquiry (SI) and scientific literacy has been and continues to be a goal of K - 12 science education. However, there have been limited assessment instruments to evaluate young children"s knowledge of SI. This workshop will (a) describe the development of two new validity and reliable instruments for K -6 students: Views About Scientific Inquiry questionnaire-Elementary (VASI-E) and the Young Children"s Views of Science (YCVS) (b) outline the framework of scientific inquiry that undergirds the VASI-E and YCVS; (c) provide training on how. to administer and score both the VASI-E and YCVS; (d) discuss the utility of soliciting rich-descriptive views of SI that these instruments provide for informing future research efforts.

Indigenous Science Knowledge (ISK-RIG)
Pre-Conference Workshop: Dismantling Systemic Inequalities in Indigenous STEM Education
4/18/23, 8:00-11:45, Off-Site

Dismantling Systemic Inequalities in Indigenous STEM Education

ORGANIZERS
Sharon Nelson-Barber, WestEd, USA
Rouhollah Aghasaleh, California State Polytechnic University, Humboldt, CA, USA
Megan Bang, Northwestern University, IL, USA
Pauline Chinn, University of Hawai`i at Mānoa, HI, USA
Josiah Hester, Northwestern University, IL, USA
Julie Robinson, University of North Dakota, ND, USA
Linda Tuhiwai Smith, Te Whare Wānanga o Awanuiārangi, New Zealand
Bhaskar Upadhyay, University of Minnesota, MN, USA
David Zandvliet, Simon Fraser University, Canada

ABSTRACT
The research landscape of today"s world is changing. This altered context is of highest interest to ISK RIG members, who are asking for bold innovations to advance racial equity and center the voices, knowledges, and experiences of Native communities in our projects. This year we are invited to the Spencer Foundation (625 N Michigan Ave). The Spencer Foundation sits on the ancestral and traditional homelands of the Council of the Three Fires: the Ojibwe, Odawa, and Potawatomi Nations. This area has also been home to other tribes such as the Miami, Ho-Chunk, Menominee, and Sac and Fox. The region has long been a center for Indigenous people to gather, trade, and maintain kinship ties. Today, one of the largest urban Indigenous communities in the United States resides in Chicago. NARST members can walk to the Foundation or travel by subway (access near the primary hotel). The schedule includes opening protocol, a welcome and orientation to the local context, a brief update on the state of Indigenous research methodologies for educational transformation, followed by a series of roundtable discussions facilitated by the ISK RIG members. ISK RIG scholars will use small

groups to discuss global science education reforms and dismantling systemic inequalities in Indigenous STEM education. Participants will add their own experiences with effective context-specific solutions toward educational transformation. Each table will produce a summary and report, along with recommended materials related to Indigenous science programs.

Other Pre-Conference Events

Board of Directors
NARST Board Meeting
4/18/23, 8:00-12:45, Waldorf (L3)

Membership Committee
Sponsored Session: Mentor-Mentee Nexus
4/18/23, 8:00-9:00, Salon A5 (LL)

Mentor-Mentee Nexus

ORGANIZERS
Elizabeth de los Santos, University of Nevada, USA
Shiang-Yao Liu, National Taiwan Normal University, Taiwan
Harini Krishnan, Florida 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 Faculty Forum - Pre-Conference Workshop
4/18/23, 9:10-10:10, Salon A5 (LL)

Early Career Faculty Forum

ORGANIZERS
K.C. Busch, North Carolina State University, USA
Harleen Singh
Brooke Whitworth, Clemson University, USA

ABSTRACT
The membership committee hosts an annual Early Career Faculty Forum. This forum will use a panel approach to introduce junior faculty members and post-doctoral fellows to peers, recently promoted colleagues, and prominent scholars. The forum will focus on the nuances of thriving during the early career years as a faculty member in science education. Our discussions will include issues of developing and maintaining a research agenda (e.g., publications & grant writing), fulfilling teaching responsibilities, and engaging in meaningful service experiences. In addition, the forum will explore many of the challenges of transitioning into new professional roles while maintaining balance in your life in the process. Following the panel, attendees will have the opportunity to participate in round table discussions for more in-depth sharing and questioning.

Membership Committee
Sponsored Session: NARST Welcome Session
4/18/23, 10:20-11:20, Salon A5 (LL)

NARST Welcome Session

ORGANIZERS
Tuğba Yüksel, Recep Tayyip Erdogan University, Turkey
Robert Bennett, Georgia State University, USA
Melanie Kinskey, Sam Houston State University, USA

ABSTRACT
The Welcome Meeting organized by the NARST Membership Committee will be a 1-hour event where new members, first-time attendees, and practitioners are provided with conference logistics as well as opportunities to 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.

Graduate Student Committee
Social Event: Graduate Student Luncheon
4/18/23, 11:45-13:00, Salon A5 (LL)

CADASE RIG
Sponsored Session: CADASE RIG Meet and Greet
4/18/23, 11:45-13:00, Salon C5-6 (LL)

Opening Session, 4/18/23, 13:00-14:45

Opening Session: Presidential Welcome
4/18/23, 13:00-13:30, Grand Ballroom (L2)

Welcome Address by NARST President Gillian Roehrig

Introduction to the NARST Board Members

Keynote Speaker: Keynote Address
4/18/23, 13:30-14:45, Grand Ballroom (L2)

Engineering Science Reform
Christine Cunningham*, Pennsylvania State University, USA

ABSTRACT
The past decade has witnessed reforms in science education across the globe. Among these has been the introduction of engineering into preK-12 standards, classrooms, out-of-school settings, and informal learning spaces. The diversity of student ideas and experiences in today's classrooms represents an opportunity to foster a generation of creative problem solvers that will shape their world. This talk explores synergies between engineering and science. It presents conceptual frameworks and equity-oriented curricular design principles for engineering education that invite participation by all learners. Curricular examples and short classroom videos illustrate how well-designed resources can engage students in authentic engineering challenges and practices that develop their engineering and science knowledge, abilities, and identities. Reflections on changes spurred by the integration of engineering and possibilities for future reform efforts are considered.

About the Speaker
Christine Cunningham aims to make engineering, science, and computational thinking education more equitable, especially for populations that are underrepresented in STEM. She is a Professor of Practice in Education and Engineering at the Pennsylvania State University. Cunningham is the founding director of Youth Engineering Solutions (YES), which develops equity-oriented, research-based, field-tested curricula and professional learning resources for preK-8 youth and their educators. Her research focuses on articulating frameworks for precollege engineering education and exploring affordances of engineering for learners. She has secured over $45 million in grants to fund her work and research. Christine's book, Engineering in Elementary STEM Education, describes her groundbreaking work in engineering education.

Previously, Cunningham was a vice president at the Museum of Science in Boston where she was the founding director of Engineering is Elementary (EiE), which reached 200,000 educators and 20 million children under her leadership. She has served as the Director of the Tufts University Center for Engineering Educational Outreach, where her work focused on integrating engineering with science, technology, and math in professional development for K-12 teachers. She also directed the Women's Experiences in College Engineering (WECE) project, the first national, longitudinal, large-scale study of the factors that support young women pursuing engineering degrees.

Cunningham currently serves as a Curriculum Specialist on the National Assessment Governing Board and the Chair of the National Academy of Engineering's Inclusive, Diverse, Equitable Engineering, for All (IDEEA) Committee. She is a fellow of the American Society for Engineering Education and has received numerous awards including the American Society of Engineering Education K-12 and Pre-College Division Lifetime Achievement Award, the IEEE Pre-University Educator Award, and the International Society for Design and Development in Education Prize. In 2017, her work was recognized with the prestigious Harold W. McGraw Jr. Prize in Education. Christine holds joint B.A. and M.A. degrees in biology from Yale University and a Ph.D. in Education from Cornell University.

Concurrent Session 1
4/18/23, 15:00-16:30

Indigenous Science Knowledge (ISK-RIG) Sponsored Session: Exploring the Potential of Locally- and Globally-Valued Knowledges
4/18/23, 15:00-16:30, Salon A5 (LL)

Exploring the Potential of Locally- and Globally-Valued Knowledges

ORGANIZERS
Sharon Nelson-Barber, WestEd, Portland, OR, USA

PANELISTS
David Zandvliet, Simon Fraser, Burnaby, BC, Canada
Julie Robinson, U of North Dakota, Grand Forks, ND, USA
Joshua Hunter, U North Dakota, Grand Forks, ND, USA
Bhaskar Upadhyay, U Minnesota, Minneapolis, MN, USA
Pauline Chinn, U Hawaiʻi, Mānoa, Mānoa, HI, USA
Paichi Shein, National Sun Yat-sen University, Kaohsiung, Taiwan
Peresang Sukinarhimi, National Sun Yat-sen University, Kaohsiung, Taiwan
Tzu yu Kuo, National Sun Yat-sen University, Kaohsiung, Taiwan

ABSTRACT
Environmental change is an enduring challenge to life as we know it. For Indigenous communities whose systems of knowledge, cultural practices, and livelihoods are deeply linked with the natural world and based on observations and experiences, rapid and unpredictable environmental changes defy their abilities to adapt to constantly changing impacts of weather and climate. Today, their predictive knowledge can be uncertain due to increasingly inconsistent conditions in their surroundings. Even so, there is value in examining how Indigenous knowledges and practices oriented to sustainable social ecosystems can complement conventional science teaching and learning. The proposed Administrative Symposium aligns with the NARST conference theme: Reflecting on Reform because project- and place-based learning involving community adaptation strategies and regionally contextualized curricula and pedagogy have potential to address the urgency of climate impacts and to provide examples of ways the Next Generation Science Standards can serve local communities and cultures, and contribute to cultivating sustainable and culturally thriving communities. Presenters from diverse cultures and geographical locations will provide global and local perspectives on Indigenous science knowledge broad enough to welcome climate discussions and research about issues of environmental justice that include collaborations among Indigenous ways of knowing and living and conventional scientific knowledge.

Concurrent Session 1, 4/18/23, 15:00-16:30

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set: Students' Use of Computational Models and Reasoning
4/18/23, 15:00-16:30, Salon C1-2 (LL)

Do different types of computational models prompt different types of reasoning?

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

ABSTRACT
Educators have been advocating for the integration of system thinking in recent years. However, thinking in terms of a system's change over time and its underlying mechanisms is a prominent aspect of system thinking which remains a challenge to many students. One of the reasons for such a challenge is a strong inclination towards linear causal thinking. Because computational modeling is claimed to be a viable approach to support students in system thinking, we examined whether using static equilibrium modeling, which is based on setting linear causal relationships between variables, can serve as a scaffold for constructing dynamic time-based models, in which the model output represents change over time output. We interviewed 13 tenth-grade high school students who participated in a curriculum unit that included both modeling approaches. We show that static equilibrium modeling prompted a linear causal explanation for the phenomenon while the time-based dynamic model prompted an explanation based on describing change over time. We also show that students testified that the static equilibrium modeling tool did not allow them to express their understanding of the phenomenon.

Right but Wrong: The Independence of Mechanistic Reasoning and Canonical Understanding in Studying Diffusion

Tamar Fuhrmann*, Teachers College, Columbia University, USA
Leah Rosenbaum, Teachers College, Columbia University, USA
Adelmo Eloy, Teachers College, Columbia University, USA
Aditi Wagh, MIT, USA
Jacob Wolf, Teachers College, Columbia University, USA
Paulo Blikstein, Teachers College, Columbia University, USA
Michelle Wilkerson, University of California, Berkeley, USA

ABSTRACT
This study explores how the interplay between data analysis and model design shifts 6th-grade students' understanding of diffusion from simple to sophisticated mechanistic reasoning and from non-canonical to canonical ideas about diffusion. Using mixed-methods qualitative analysis, we determine students' mechanistic reasoning and ideas about diffusion at five different points in a curricular sequence using a new tool for computational modeling called MoDa. With this data, we present a framework for the relationship between students' developing mechanistic reasoning and their canonical understanding, suggesting that they develop independently. Further, we illustrate how the computational modeling environment, MoDa, used in this study pushed students' mechanistic reasoning toward sophistication.

Moreover, in allowing them to explore non-canonical mechanisms, MoDa supported their convergence on canonical scientific ideas about diffusion.

Supporting Learners to Evaluate Computational Models: Mechanistic Reasoning about Machine Learning

Anna Kim*, Pennsylvania State University, USA
Amy Farris, Pennsylvania State University, USA

ABSTRACT
Reasoning about mechanisms has a longstanding prevalence in studies of scientific modeling (e.g., Bechtel & Richardson, 2010; Machamer et al., 2000), and in science educational research (e.g., Russ et al., 2009; Krist et al., 2019). However, supporting students to test and evaluate models of how systems work remains a significant challenge in science education research (Schwarz et al., 2009; Wilensky & Reisman, 2006). In this study, we engaged a group of 23 non-science major teacher candidates (TCs) in their final year of teacher preparation coursework in a series of activities in which they explore machine learning (ML) systems that are designed to recognize images. They were attempting to model how the systems work. We found that modeling, learning about, and exploring ML systems—specifically games for image recognition—supported the TCs' mechanistic reasoning and provided opportunities for the TCs to think critically about their explanatory models and the ML systems, including the ML training processes, and to engage in testing and evaluating both their own explanatory models and the computational ML systems they were describing. We also found that the TCs were able to describe how learning about ML could support their future students' engagement with science and engineering practices.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Science Teaching & Instruction
4/18/23, 15:00-16:30, Salon C3-4 (LL)

Physics and Wine: an amazing everyday context for science teaching even without alcohol

Lutz Kasper*, University of Education, Physics Dept., Germany
Patrik Vogt, Institute for Teacher Education (ILF), Germany

ABSTRACT
The authors collected and developed 50 mostly physics-related wine experiments. This collection was firstly published as a popular science book (Authors, 2022) and includes perspectives from mechanics, optics, thermodynamics, acoustics, and chemistry. Starting with determining the velocity of sound while opening a wine bottle and ending with an unexpected flame direction while blowing out the candlelight at the end of the party, many phenomena are presented and explained. So, this talk will provide science teachers from secondary level up to colleges with amazing every-day contexts. There is no need for using real wine or alcoholic liquids. The vast majority of experiments can be performed with water and simple household objects. From this rich collection the authors are going to develop a science lab environment with experiments that can carried out at home. The presentation provides insights into the

collection of experiments and outlines an online learning environment that also enables home-based experimentation. Thus, the students are offered authentic problems and they become familiar with science topics through activities in everyday situations. Furthermore, a study is planned to investigate the relationship between students' situated interest and instructional design.

Qualitative Cases of Science Teaching Practice: Comparing Instruction Based on Value-Added Ratings.

Elif Özülkü*, University of Notre Dame, USA
Matthew Kloser*, University of Notre Dame, USA
Aria Malkani, University of Notre Dame, USA
Spencer Bullinger*, University of Notre Dame, USA
Lauren Ostdiek*, University of Notre Dame, USA
Catherine Wagner*, University of Notre Dame, USA

ABSTRACT

This study seeks to reveal a deep understanding of what happens in effective science classrooms by taking into consideration both value-added measures (VAMs) of high school biology teachers based on Biology American College Testing scores as well as analyzing videos of what happens in these classrooms in both ‘normal' classroom periods and explicitly defined ‘lab' periods. We use the extensive Measures of Effective Teaching video library of teaching practice and the related VAM scores for teachers – a significant data set that has been explored deeply for math and literacy classrooms but remains only partially explored with the science data. In our preliminary analysis, we see only dyadic interactions in the high VAM-high task implementation classroom, but students are continuously forced to do the thinking in an environment of uncertainty, justify their thinking, and do so in relation to a core science idea. In contrast, the comparatively low VAM classroom with high task rating also put students in a position to engage with material activity that could help them figure out a science idea, but the teacher often released the students from doing the thinking and ultimately, the outcomes of the investigation were focused narrowly on a less-than consequential science idea.

How Convincing Are Experiments? A Comparison of Eight Interactive Videos

Lion Glatz*, Goethe University Frankfurt, Germany
Roger Erb, Goethe University Frankfurt, Germany
Albert Teichrew, Goethe University Frankfurt, Germany

ABSTRACT

The particle model of matter is an integral part of secondary school science education. After having selected several experiments that can be considered useful in conveying adequate conceptions about the particle model of matter, they are now being evaluated in the form of interactive video experiments that can be carried out autonomously by secondary school students. The results of our intervention study carried out in five German 8th grade classes (N=153) show that while it cannot be said that the experiments collectively lead to a higher conceptual knowledge about the particulate nature of matter, some experiments are more convincing than others. Our findings suggest that these differences in persuasiveness are tied

to how cognitively demanding it is for the students to process the experiments' key findings. The results of the measured intrinsic cognitive load, however, suggest that students link the cognitive demand to the experimental setup.

Science Teachers' Noticing of Science and Engineering Practices: Does Being Out-of-Field Matter?

Harleen Singh*, California State University Stanislaus, USA
Hatice Ozen-Tasdemir, University of Georgia, USA
Yuzi Huang, University of Georgia, USA
Joeseph Deluca, University of Georgia, USA
Julie Luft, University of Georgia, USA
Brooke Whitworth, Clemson University, USA

ABSTRACT
This study explores in-service, in-field, and out-of-field secondary science teachers' knowledge of science and engineering practices (SEPs), and other practices important to science instruction. The framing of this study lies in teacher noticing. Teachers draw on their prior knowledge as they choose to pay attention to specific events and further interpret these events. The participants of this study are 37 science teachers from ten states in the United States. Data was collected in the form of video-based interviews. Each teacher watched a ten-minute video clip of a middle grades physical science teacher, teaching photovoltaics. Within this video, students engaged in different SEPs. Structural coding was used to code the interviews. Coding included both labeling and indexing of data. Apriori codes were developed based on prior work. Participating teachers were placed in one of the three categories of in-field or out-of-field based on their degree subject, teaching certification, and teaching assignment. Teachers were further categorized as watching the video in-context or out-of-context based on their teaching assignment, preparation, and area of video watched. Analysis of the data reveals a difference in noticing the SEPs and other science practices based on teachers' preparation and experiences with teaching physics/physical science.

Strand 4: Science Teaching - Middle and High School (Grades 5-12): Characteristics and Strategies
SC-Organized Paper Set: Academic Language, Argumentation, and Science Teaching
4/18/23, 15:00-16:30, Blvd A (L2)

Expanding sensemaking spaces for multilingual students through translanguaging instructional practices

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

ABSTRACT
Reform-oriented science instruction centers sensemaking responsibility on students. Through this instructional approach, the teacher plays a critical role in supporting students in working together to figure out ideas about the natural world. The various processes that occur as students engage in scientific sensemaking require that they use language - across both linguistic and semiotic modes of communication - in complex ways. As such, teachers need to have nuanced and expansive understandings of the relationship between language and scientific sensemaking, and associated instructional practices to ensure that all students - particularly, multilingual students - authentically engage with, make sense of, and communicate science ideas. Adopting a translanguaging lens, this exploratory study investigates a teacher's instructional practices for addressing language use for scientific sensemaking. Findings revealed that the teacher's instructional practices fell into three categories: (1) those in which the teacher used languaging for sensemaking; (2) those in which the teacher prompted students to use languaging for sensemaking; (3) and practices in which the teacher raised meta-languaging awareness. These moves not only expanded sensemaking spaces for multilingual students, but they also elevated competing student ideas, helping further the class's sensemaking work as students grappled over which idea was best substantiated by evidence.

"The Dead Sea is Dying" - Language-Sensitive Science Teaching for Students with Diverging Language Competences

Robert Gieske*, Freie Universität, Germany
Claus Bolte, Freie Universität, Germany

ABSTRACT
In order to investigate the effects of an innovative approach to teaching scientific concepts and terminology called Disaggregate Discourse Approach to Science Instruction (DDASI) developed by Brown et al. (2010), we conducted a treatment-control study with a pre-post-test design. 228 students from public regular and academic high schools participated in the teaching sequence "The Dead Sea is Dying" which we designed in alignment with the four phases of the DDASI in the treatment group and with identical content and language-sensitive methods but no reference to the DDASI in the control group. In the accompanying subject-matter knowledge test, the DDASI students outperformed the control group but the differences are not statistically significant. If we split up the total sample at the median score of the c-test (which was part of the pre-test) into a group with lower and a group with higher language competences, we detect a higher learning growth in the treatment condition compared to high-quality, language-sensitive instruction without a "disaggregation" for students with lower language competences. While this difference does not exhibit statistical significance, it is significant when only regular high school students are considered.

Evolving Language in Middle School Project-Based Astronomy

Merryn Cole*, University of Nevada, Las Vegas, USA
Tom Ryan*, University of Nevada, Las Vegas, USA
Jennifer Wilhelm*, University of Kentucky, USA

ABSTRACT
Under the Next Generation Science Standards, middle school students are expected to model Earth-Moon-Sun motions to explain Moon phases, eclipses, and seasons (NGSS Lead States, 2013). Using a phenomenography lens, we investigated the ways in which students seeing the Moon in nature and related classroom experiences translate into a mental model of lunar phases. Eighth-grade students from three urban middle school classrooms were assessed for spatial ability and understanding of lunar phases. Girls and boys of both high and low spatial ability were interviewed to explore their Moon phase understanding and causal thinking before and after an astronomy unit. One school employed the school district's astronomy curriculum while the other used the (unit). Students engaged in babbling (i.e., inarticulate but somewhat correct descriptions) and gargling (i.e., using many technical terms without evidence of understanding) with much greater frequency in pre-interviews. Students who developed correct vocabulary and used it comfortably in interviews were more likely to also display correct Moon phase conceptions. (Unit)'s project-based approach to teaching astronomy and related vocabulary through hands-on, contextualized projects and activities (e.g., moon observation journals) produced greater vocabulary gains.

Does learning how to deal with data lead to more scientific argumentation?
Engin Kardas*, Karlsruhe University of Education, Germany
Tobias Ludwig, Karlsruhe University of Education, Germany

ABSTRACT
In preliminary work, the authors (2017) analyzed students' argumentation while experimenting, showing that more content knowledge of mechanics leads to more adequate reasoning and justifications. Furthermore, Kanari and Millar (2004) showed the importance of understanding data and uncertainties for scientific reasoning. Hence, we assume that when conducting analyses and establishing arguments based on experimental data, domain-specific content knowledge (DCK) of how to handle data and measurement uncertainties (MU) is relevant. Therefore, 12 digital learning apps were created to foster students' DCK of data and MU__. The apps' efficacy showed a Cohen's d of 0.5 < d < 1.4 _ (Authors, 2021). In a longitudinal study (n = 325), students' justifications before and after the intervention with the digital learning apps were analyzed. Students were given experimental data and had to determine the relationship between periodic length and pendulum mass (Authors, 2019). The results showed that DCK of data and MU could be fostered with a moderate effect. Furthermore, the findings suggest that more DCK of data and MU leads to more adequate argumentation: Students justified claims less intuitively and based more on evidence. Finally, the results showed that justification based on evidence leads to an increased likelihood that hypotheses are correct.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: STEM Student Sense of Belonging and Identity Development
4/18/23, 15:00-16:30, Salon C5-6 (LL)

Factors Associated with Undergraduate Students' Sense of Belonging in STEM Disciplines

Gili Marbach-Ad*, University Of Maryland, USA
Sara Gliese, University Of Maryland, USA
Katerina Thompson, University Of Maryland, USA

ABSTRACT

Student attrition is a major concern within Science, Technology, Engineering, and Mathematics (STEM) undergraduate programs, with only about half of the students that enter actually completing a degree in STEM. One potential protective factor against student attrition is sense of belonging, which has been linked to degree completion. As such, it is important to examine what factors may contribute to sense of belonging in students from STEM disciplines, such as their demographics, values, and experiences. We examined this relationship for students belonging to five STEM disciplines (Biological Sciences, Mathematics, Physics, Computer Science, and Chemistry) using senior exit survey responses collected over the course of two years (N=1132). Additionally, we interviewed students from each discipline to contextualize and elaborate upon survey responses. Analyses identified differing factors as predictive of sense of belonging for each discipline. For example, Computer Science students' experiences were more significant predictors of belonging; whereas, for Biological Sciences students, values were more significant. Interview data collected for Biological Sciences students revealed themes of being able to connect with peers as promoting belonging, and feeling that classes were unnecessarily challenging (e.g., weed-out courses) and doubting their own abilities (e.g., imposter syndrome) as decreasing belonging.

Students' sense of belonging in a community of practice fosters scientific literacy and identity formation.

Josie Smith, Colorado State University, USA
Gary McDowell*, Lightoller LLC, USA
Meena Balgopal, Colorado State University, USA
Rebeccah Lijek, Mount Holyoke College, USA

ABSTRACT

Undergraduate education on science publishing and peer review is limited compared to the focus on experimental research experiences. Since peer review is integral to the scientific process and central to the identity of a scientist, we envision a paradigm shift that makes teaching peer review integral to undergraduate science education, as it may facilitate the development of students' scientific identity. To this end, we developed a biology curriculum for undergraduates to learn about the mechanisms of peer review, then write and publish their own peer reviews as a way to authentically join the scientific community of practice. We measured students' scientific literacy and scientific identity using thematic analysis of students' writing. We present data on the curriculum's interrelated impact on students' sense of science identity, literacy, and belonging in academic and professional spaces. We propose that belonging in a CoP is dependent on the interplay between literacy in the practices and discourses of the community, and on identity as a member of that community. We posit that undergraduate instructors should design curricula to allow students to reflect on their identities and sense of belonging in both the classroom as well as in the broader science CoP.

Exploring a Relationships between Students' Science Identities and Achievement Emotions in Physics

Mihwa Park*, Texas Tech University, USA

ABSTRACT

We explored the relationship between achievement emotions and science identities in an inquiry-based physics class. We adapted the Achievement Emotions Questionnaire-Mathematics by replacing all references to mathematics with physics and selected items from the PRiSE survey. The adapted instruments were implemented with students in an inquiry-based physics class. The results showed that overall students did not perceive them as science persons, especially in chemistry or physics. Students' anxiety levels were increased in a test-related situation compared to class-related and learning-related situations. In terms of the relationships between their science identity and their emotions, students' self-identification and their perceptions about their parents/relatives/friends' views about them as physics persons were significantly related to their emotions in physics.

Introduction to Primary Literature Course: Impacts on undergraduate students' science identity and interest in research

Takunda Maisva*, Syracuse University, USA
Mariah Maxwell*, Syracuse University, USA
Jason Wiles, Syracuse University, USA

ABSTRACT

Introduction to Primary Literature (IPL) courses have been designed as a more accessible alternative to traditional research experiences in an effort to introduce undergraduate students to research in the classroom setting. IPL courses have been shown to increase student science self-efficacy and understanding of the nature of science at the same level as Course-based Undergraduate Research Experiences (CURE) and Faculty-Led Research Experiences (FLRE). Further research is needed to understand how an IPL course can impact the science identity, or extent to which one relates to science, of undergraduate students. Science identity is important because having a strong science identity has been associated with student success and persistence in STEM degree programs. The proposed study used a quasi-experimental, mixed methods approach to understand the impacts of engaging with the products of research through reading primary research articles, communicating scientifically, and interacting with scientists of various levels on the science identities of undergraduate students enrolled in a seminar-style biology IPL course at a large, private, research-intensive institution in the Northeastern United States. Pre- and post-course surveys, as well as a group interview, were used to collect student information and measure the science identity of willing participants.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set: Families and Play in Contributing to STEM learning
4/18/23, 15:00-16:30, Blvd C (L2)

How Families' Make Learning Personally Relevant while Using a Pollinator-focused Mobile Augmented Reality (MAR) app

Lucy McClain*, Penn State University, USA
Heather Zimmerman, Penn State University, USA
Susan Land, Penn State University, USA
Stephanie Bowles, Penn State University, USA
Charles Keith, Penn State University, USA
Lillyanna Faimon, Penn State University, USA
Yu-Chen Chiu, Penn State University, USA

ABSTRACT
Mobile augmented reality (MAR) technologies have the potential to support families in deepening their understandings of place-based phenomena through augmentation of digital content onto real-world objects (Authors, 2021; Yun et al., 2022). Yet there has been little focus on how families shape these guided learning experiences to fit their unique ways of knowing and making meaning of the world around them. Using video-based qualitative methods to analyze nine families' experiences using a learning-on-the-move MAR app focused on pollinator habitats, our research group explored how the families made learning personally relevant by leveraging prior knowledge and experiences in their conversations. Results of this analysis highlight how the families actively curated a personally relevant learning experience while using the app. Additionally, we found that six distinct design features within the MAR app triggered these personally relevant conversations for the families. Members of NARST (Strand 6: Science Learning in Informal Contexts) will find this work to be of interest as family groups are one of the most common social learning groups to visit informal science institutions. With a rise in mobile technology access and use comes a more invested interest in how family learning is shaped in different educational settings.

Play: The Missing Link for Beginning STEM Learning

Sue Tunnicliffe*, UCL, United Kingdom
Yinka Ogunlade, Ekiti State University, Nigeria
Adekunle Oladejo, 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
Juma Shabani, University of Burundi, Burundi
Rose Agholor, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Angela Irene, National Universities Commission, Nigeria
Deborah Agbanimu, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria

Bugoma Suwadu, University of Burundi, Burundi

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, a longitudinal one spanning six years employed a non-participant observer methodological approach, within several contents where children are able to explore STEM concepts. This involved three boys and one girl from less than one to four years in play activities formally within the home setting. The result showed that the children's attention and interest were caught, maintained and sustained from the earliest years to adulthood in STEM Experiences (STEM-E). 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.

Parents as STEM Facilitators: Perspectives following a Parent/Child Workshop Series
Meghan Marrero*, Mercy College, USA
Kristen Napolitano*, Mercy College, USA
Amanda Gunning, Mercy College, USA

ABSTRACT
Historically excluded groups have less access to STEM learning, but families of all cultures hold funds of knowledge in STEM that can be leveraged to support their children's STEM learning. This qualitative case study examines data generated from the implementation of a parent/child STEM workshop series held in five school districts over nine years. The researchers found that after participation, parents 1. held broadened views of science, seeing science as more accessible; 2. used new communication strategies to facilitate STEM learning with their children; and 3. identified and leveraged more STEM learning opportunities in their homes and communities. This study has implications for broadening participation in science and STEM.

Cohetes y Rábanos /Rockets and Radishes: Pilot Participant Perspectives of Parent-Daughter Programs
Peter Rillero*, Arizona State University, USA
Margarita Silva*, UC Davis, USA
Mila Librea-Carden*, University of North Texas, USA

ABSTRACT
This study examined participant perspectives of six pilot programs, for two different seven-week curricula, for supporting parents and their Latina daughters, featuring Family Problem-Based Learning with themes of rockets or gardens. Separate parent and daughter Conversation Groups were a part of the programs, held in two different Western states. While simultaneously valuing the antecedent Community Cultural Wealth, science capital, and family

habitus of participants, the programs providing opportunities for growth in these areas. Thirty-nine families completed one of the pilot programs. The mid- and post-survey data suggest that parents and daughters had positive views of the program. Parents and daughters felt comfortable and supported, enjoying working on the activities together, and indicated that they would recommend the program to friends. Participants expressed that the activities promoted interaction between parent and daughter and valued observing other families doing activities. These data are supported by open-ended statements by the participants. On the retrospective items, girls indicated gains in their liking of science, science interest, and considering science careers, which are important dimensions of science capital. They also had a greater appreciation for doing science with their parents and for their parents' abilities in science, which are important dimensions of familial capital.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Supporting Inclusive, Equitable, and culturally responsive Teaching
4/18/23, 15:00-16:30, Salon A2 (LL)

Development and use of assessment tool to understand equity outcomes in a teacher education program

Allyson Rogan-Klyve*, Central Washington University, USA
Adrienne Pinsoneault*, Central Washington University, USA
Danielle Wadlington*, Quetzal Education Consulting, USA
Jennifer Dechaine, Central Washington University, USA

ABSTRACT
Teacher racial demographics in the United States do not match student demographics. For example, recent data show that approximately 80% of public school teachers in the United States identify as white, while less than half of the student population identifies as white. Teacher preparation programs have a multi-faceted role to play in addressing this lack of diversity in the teacher workforce, but can prioritize taking steps to ensure equitable outcomes in their own programs. This case study describes the development and use of an assessment tool by a math and science teacher education program in order to better understand the equity outcomes of the program. In addition to describing the development of the tool, analysis of data resulting from the use of the tool as well as the resulting impact on the teacher education program are included. This case study aims be informative for science teacher educators and provide examples of tools and strategies programs can use to create more equitable outcomes for future teachers and the students they will teach.

Noticing for Equity: Supporting Preservice Science Teachers for Inclusive and Equitable Teaching

Mutiara Syifa*, The Ohio State University, USA
Sophia Jeong, The Ohio State University, USA
Ashlyn Pierson, The Ohio State University, USA

ABSTRACT
In recent years, science teacher educators and researchers have called for equitable teaching. One aspect of exploring equitable science teaching and learning is helping preservice teachers develop their professional vision (Goodwin, 1994) and thus their noticing abilities. Originally theorized in mathematics education, very few studies have explored this construct of teacher noticing in science education. This study explores a preservice teacher's noticing for equitable and inclusive teaching in science teacher education. We used a case study methodology to explore how a preservice science teacher (PST) identifies and responds to equity issues in science teaching and learning. We draw on a methodological framework of Attending, Interpreting, Responding (AIR) in order to operationalize teacher noticing in the context of a middle school STEM methods course. Findings showed that PST developed abilities to notice issues around equity related to history, race, justice, and language matters during the methods course and a structured video analysis activity, which provided an opportunity for PST's to reflect on their teaching to be more equitable. We argue that science teacher programs that focus on noticing equitable teaching practices can help PST to be more prepared to address equity issues that operate in the school setting.

Exploring Culturally Responsive Teaching in an Urban Teacher Residency Through Program Structures

Elaine Howes*, American Museum of Natural History, USA
Jamie Wallace*, American Museum of Natural History, USA

ABSTRACT
In this study, we explore efforts to prepare culturally responsive science teachers in an urban residency model. In the comparatively young program described in this paper, some structures were in place at the inception of the program (e.g., multiple residencies); residency-based assignments and program tools have evolved over time as the program clarified its goals and responded to ongoing policy and societal conditions. We use a qualitative case study approach to explore in what ways the residency plays a role in supporting learning of culturally responsive science teaching in high-needs schools, from the perspectives of the program's main stakeholders—faculty, mentors, and graduates. All participant groups mentioned program structures as important in supporting CRE learning in the residency, which included the structure of three distinct residency experiences: a summer ISI teaching residency, and two different school-based residencies. Additional structures mentioned were residency-based course assignments, program tools, and observations and debriefs with faculty supervisors in schools. We argue that paying attention to program structures can help to gain a deeper understanding of urban residency programs' endeavors to promote CRE for prospective teachers for high-needs schools.

Investigating Teacher Educator Practices for Pre-Service Teachers' Enactment of Justice-Oriented Science Teaching

Grace Tukurah*, Michigan State University, USA
Matthew Adams*, Michigan State University, USA
Kate Miller*, Michigan State University, USA

ABSTRACT
The general climate of education as a microcosm of larger society demands that teachers pay greater attention to, and are adequately equipped to engage with matters of social justice in humanizing and culturally relevant ways. This paper speaks to the role of science teacher educators in preparing science teachers to take on the work of equitable, inclusive, and justice-oriented science teaching. We offer a conceptual framework, Justice-Oriented Science Teaching (JOST), consisting of four tenets: 1) rigorous academic expectations, 2) a humanizing approach to teaching, 3) use of science education for social transformation, and 4) critical consciousness among secondary science preservice teachers. Using this framework, we conducted a qualitative critical self study of one year of teaching a science methods course to understand how secondary science preservice teachers engaged with JOST and the implications of this engagement in their respective teaching practices. Data used for this study included student classwork (unit plans, teaching philosophies), student reflection journals, and post-course exit interviews. We found that while all of the preservice teachers (N=11) had expectations of academic rigor in their teaching practice and embraced humanizing approaches, there was variation in their critical consciousness and understanding of science teaching for social transformation.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Exploring Knowledge and Pedagogical Content Knowledge Development in Preservice Teacher Education
4/18/23, 15:00-16:30, Salon A3 (LL)

Supporting Preservice Teachers' Science Content Knowledge for Teaching (CKT)
Dustin Van Orman*, Western Washington University, USA
Josie Melton*, Western Washington University, USA
Deborah Hanuscin*, Western Washington University, USA
Daniel Hanley*, Western Washington University, USA
Katherine Castellano, Educational Testing Service (ETS), USA
Jamie Mikeska, Educational Testing Service (ETS), USA
Emily Borda, Western Washington University, USA

ABSTRACT
Knowledge of science content and the ability to translate knowledge into effective teaching is known as teachers' content knowledge for teaching (CKT). Research repeatedly demonstrates that teachers who possess significant CKT are able to more effectively determine instructional and assessment activities that will deepen students' scientific literacy. Over the course of five years, we developed active and student-centered instructional materials, a learning community of teacher educators (TEs) across the U.S., and a robust assessment of CKT around matter and its interactions to help TEs develop pre-service teachers' (PSTs) CKT. We report on results from a mixed-methods study using a quasi-experimental cohort control design with a pre- and posttest to understand differences in PSTs' CKT (N = 280) in eight TEs' science classrooms.

After controlling for PSTs' prior CKT, engagement on the assessments, and prior coursework, we found that TEs who implemented more packets observed greater gains in their PSTs' CKT. We discuss salient factors that influenced TEs' productive uses of packets in helping PSTs develop CKT in their science courses.

Pedagogical content knowledge and content knowledge in elementary in-service teachers.

David Santibáñez*, Universidad Finis Terrae, Chile

ABSTRACT

Despite the critical role elementary teachers have in science education, little has been studied about the relationship between their conceptual knowledge (CK) and pedagogical content knowledge (PCK) on specific science topics. This is relevant since elementary teachers have few opportunities to learn scientific content during training. However, they must be able to teach numerous science concepts. This study aims to know the relationship between the CK and the PCK of in-service elementary teachers on a specific topic. To that end, a CK test on the human body was designed, and a PCK rubric based on the Gardner and Gess-Newsome (2011) model, involving both declarative and procedural PCK, was developed. Both instruments were applied to 13 in-service elementary teachers. According to the results, there seems to be a minimum CK level on which elementary teachers build their PCK. Possible explanations and the consequences of this finding on the professional development of elementary teachers are discussed.

The influence of cPCK- and pPCK-Scaffolds on video analysis skills in early pre-service teacher education

Marie Irmer, Ludwig-Maximilians-University, Germany
Dagmar Traub*, Ludwig-Maximilians-University, Germany
Christian Förtsch, Ludwig-Maximilians-University, Germany
Birgit Neuhaus, Ludwig-Maximilians-University, Germany

ABSTRACT

The Refined Consensus Model of PCK is the most recent model describing the professional knowledge of science teachers. It identifies three realms of PCK: the cPCK, the pPCK and the ePCK. The ePCK includes the plan-teach-reflect cycle. Video-based tools offer the opportunity to bring practical insights to pre-service teacher (PST) education. Our video-based simulation was already successfully used to train PSTs' PCK. Including PCK-scaffolds in the simulation was proved to be effective for fostering PSTs' video analysis skills. The competence assessed with the simulation can be assigned to the pPCK/ePCKreflect of a teacher. We conducted a pre-post-study with 78 PSTs with the aim to investigate what type of scaffold (cPCK- or pPCK-scaffold) supports PSTs best in improving their video analysis skills. We also measured the PSTs' cPCK. All PSTs included in the study have little prior PCK. The PSTs receiving pPCK-scaffolds in the intervention significantly improved their video analysis skills. The cPCK-scaffold did not lead to a significant improvement. The cPCK of the PSTs did not change, regardless of the treatment. We conclude that supporting the PSTs' pPCK helps them to build

up and improve their pPCK/ePCKreflect. Training these skills does not improve the PSTs' cPCK.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Asset Perspectives of In-Service Teacher Education Towards Equitable Teaching
4/18/23, 15:00-16:30, Salon A1 (LL)

Adapting Designed Curriculum to Local Contexts through Professional Learning Communities

Cory Miller*, Michigan State University, USA
Kathryn Bateman*, Michigan State University, USA
Joseph Krajcik, Michigan State University, USA

ABSTRACT
Designing curricular materials that meet all classrooms' needs requires materials to be adaptable to the local context and capitalize on the expertise of teachers. We examine a case study of three experienced teachers' adaptations of a designed curriculum to ascertain what kinds of adaptations were made and why, and what resources supported teachers in adapting curricula. Teachers most frequently made pre-planned adaptations within lessons. These adaptations responded to the students and teachers immediate needs such as adjusting reading levels of text, shortening lessons for time, or building on students' ideas. In interviews, teachers expressed feeling supported by their involvement with the professional learning community that included teachers and researchers. To adapt, teachers had to exercise agency over their classroom practices and the PLC was a trustworthy space in which they could be vulnerable. Teachers expressed that the professional learning sessions created spaces to talk with other teachers, but they also valued the ability to informally communicate and discuss adaptations and curricular materials with the research team. We believe by creating PLCs that foster agency, we can support teachers in using their knowledge and skills to move towards more equitable instructional decision making.

Using video reflection as research tools to more equitably engage students and families

May Lee*, The Pennsylvania State Univers, USA
Jennifer Cody, The Pennsylvania State Univers, USA
Carla Zembal-Saul, The Pennsylvania State Univers, USA

ABSTRACT
How do teachers and researchers develop meaningful and sustaining partnerships? Building and strengthening relational trust is at the heart of this case study, which explores how teachers and researchers co-designed the curriculum for an after-school STEM program. The teachers' critical reflections on the curriculum foster the research-practice relationship in conjunction with the researchers. Despite three years of relationship building, teacher vulnerability was still present. Through videos to guide reflection, we use a transformational learning theory lens to understand how relational trust changed over time.

Envisioning equity: Teacher conceptualization of an inclusive science classroom
Jackson Jackson, The Pennsylvania State University, USA
Brandin Conrath*, The Pennsylvania State University, USA
Scott McDonald, The Pennsylvania State University, USA

ABSTRACT
At the present moment, the issue of race is of dire importance within the science classroom thus supporting the fact that there has been a recent focus on the idea of equity within science education, more specifically, the acknowledgment of identity and how past experiences can aid one's learning. This focus should be widened to include teacher education and how in-service teachers (ISTs) should strive for the development of an inclusive learning environment. For this study, we challenged teachers to acknowledge their own identities and past experiences, so that they would be better equipped to consider the aspects of an equitable learning space. By applying the theory of Professional Vision, our analysis involves considering how teachers are choosing to attend to specific components of the professional development workshop as well as how they are applying meaning to those aspects. Finally, this study presents useful findings towards the understanding of how teachers may rely on their own identities and past experiences when determining how to best create an inclusive learning space that integrates culturally responsive and relevant teaching practices.

Designing a More Socially Just Science Through Community Mapping
Kathryn Bateman*, Michigan State University, USA
Jonathan McCausland*, New Mexico Highlands University, USA

ABSTRACT
Research with mapping communities has promise for fostering critical approaches to ambitious pedagogy, however, in-service teachers (ISTs) need ways to learn these methods. Given this, we designed a professional learning community for ISTs to use walking tours and mapping as a method to foster asset-based pedagogies. As part of a design-based study, teachers and the authors met bi-weekly during the 2021-2022 school year. Initially, teachers used the maps of their local communities, created in conjunction with students, parents, or community members at large, to determine what is important to their students within their content areas. After participating in walking tours and mapping their findings, teachers came together to think about phenomena around which they could then build STEM units, settling on environmental justice phenomena that could be applied across disciplinary silos. Throughout unit development, teachers were drawn to creating engineering design challenges to solve localized problems. We see this work as contributing to the ideas about what it means to do asset-based approaches to education as it positions both teachers and communities as assets.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set: Promoting quality in science education with evolutionary assessment
4/18/23, 15:00-16:30, Astoria (L3)

The PISA Science Assessment for 2025

Jonathan Osborne*, Stanford University, USA

ABSTRACT

Science is the major focus of the OCED PISA tests in 2025 which is taken by 81 countries This paper offers a description of the new framework providing an explanation of the rationale for the changes and improvements from the 2015 framework. Three major changes have been made. First, the previous three competencies have been reduced to two by merging the 2nd and 3rd competency in the 2015 framework into one new competency. A new third competency has been added which focuses on the ability to research and evaluate scientific information. Second, the impact of climate change and the need to consider issues of sustainability have led to a new competency – Agency in the Anthropocene which draws on elements of the science framework. Third, the framework is now considered to be a framework for the outcomes of all science education – and not just a focus on science literacy. In this presentation, the arguments for these changes will be presented and the implications for curricula and assessments considered. Given the policy significance of these assessments, this presentation will be of interest to a wide number of participants.

A data-driven justification for scientific inquiry in promoting students' scientific literacy

Jing Lin*, Beijing Normal University, China
Weiwei He, Beijing Normal University, China
Letong Zhang, Beijing Normal University, China
Ren Liu, Shandong University, China

ABSTRACT

Scientific inquiry reflects the nature of science. However, the value of inquiry-based teaching was once doubted, which led to the gradual silence of scientific inquiry in the science classroom. This study defends the critical role of scientific inquiry in students' scientific literacy proficiency through empirical data from reliable and valid measurements. The results prove that higher scientific inquiry ability, better in understanding and applying scientific knowledge, and stronger interest in science learning. Higher students' scientific inquiry ability, the higher the scores in many aspects too, such as lifestyle, health, teacher-student relationships, academic expectation, and education satisfaction. Furthermore, this study confirms that as long as teachers encourage students to engage in inquiry, they can make a certain difference in improving students' scientific inquiry ability, with students' interest in science learning playing a mediating role. Compared with conducting effective inquiry-based teaching, verbally encouraging students to participate in scientific inquiry is more feasible for teachers to put into practice immediately to benefit students. While the data for this study come from China, the findings may inspire science teachers across countries to revalue the crucial, dominant role of

scientific inquiry in promoting students' science learning and cultivating scientifically literate citizens.

A new instructionally-meaningful rubric designed for the NGSS

Jill Wertheim*, WestEd, USA
Lauren Stoll, WestEd, USA
Cathy Zozakiewicz, WestEd, USA

ABSTRACT
Assessments that can guide teachers' decisions about how to support their students' use of the NGSS dimensions to make sense of phenomena are integral to effective implementation of the new standards. Despite much progress around the design of such assessments, there has been little attention focused on how to design the interpretation systems that are used to guide analysis of the complex student work produced by 3-dimensional assessments. Analysis of common systems revealed strengths and weaknesses of each for meeting the design principles that guide NGSS performance assessments. In this paper, we describe a set of principles to guide the evaluation and design of equity-seeking rubrics for NGSS and a new type of rubric constructed to provide instructionally-meaningful information to guide 3D teaching and learning and initial observations of ways teachers are using the rubric to thread performance assessments into an equitable 3D instructional practice.

Reality Vs Expectations of Assessment in STEM Education: An exploratory case study

Mohamed El Nagdi*, American University in Cairo, Egypt
Gillian Roehrig*, University of Minnesota, Twin Cities, USA

ABSTRACT
In this exploratory case study, the assessment methods planned and used in Egyptian STEM schools were explored. The purpose of the study was to explore and check the relationship between the ideals provided in STEM education both from research and policy documents and the real assessment techniques used both at the classroom level and final exams in order to find out how far there is a constructive alignment between the proposed lofty goals of STEM and the modes of assessment used. Teachers in Egyptian STEM schools were surveyed and interviewed to explore this relationship. Samples of their assessment was examined as well. Teachers were found to have been using a bipolar model of assessment techniques; a set of assessment at the disciplinary level and another set at multidisciplinary level including, but not restricted to, project based, problem, based, inquiry, analysis, and journaling reflection. However, the continuing commitment to rigor and quality of assessment is marred by the inability to seamlessly move between both poles (disciplinary and multidisciplinary) causing a gap between both poles. As a result, the alignment between expectations and reality explored in this study was partially achieved.

Strand 11: Cultural, Social, and Gender Issues
Symposium: Equity in STEM Education Research and Praxis Post "2020"
4/18/23, 15:00-16:30, Salon A4 (LL)

Equity in STEM Education Research and Praxis Post "2020"

Tia Madkins*, The University of Texas at Austin, USA
Natalie King, Georgia State University, USA
Andrea Dziengue, Georgia State University, USA
Remy Dou*, Florida International University, USA
Heidi Cian*, Florida International University, USA
Terrell Morton*, University of Illinois Chicago, USA
NaTashua Davis, University of Missouri, USA

ABSTRACT
This symposium features five presentations that discuss how the field of science education should critically reflect on its conceptions and implementation of equity within research and praxis. In reviewing perspectives of equity from preservice teachers, early career teachers, families and communities, early career scholars, and STEM program administrators, the authors call for critical, conceptual definitions of equity that specifically center the lived experiences of those marginalized.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Antiracist Science Teaching: Resistance, Conscientization, and Critical Hope
4/18/23, 15:00-16:30, Waldorf (L3)

Relationships as Resistance: Pedagogy and Praxis Among Black STEM Teachers from Alternative Pathways

Mia Pungello*, Davidson College, USA
Brittany Murray, Davidson College, USA
Terrance Burgess, Michigan State University, USA
Jerry Wilson, University of North Carolina, USA

ABSTRACT
Black teachers have a positive influence on the academic outcomes of Black students (Gershenson et al 2018; Kohli 2009). This is particularly important in the fields of science, technology, engineering, and mathematics (STEM), as Black teachers are severely underrepresented in these areas and are less likely to receive degrees in STEM (Collins 2018). However, there is no agreement around the specific practices Black teachers perform in and outside the classroom that have an effect on their students. Additionally, there has been insufficient research to understand the specific approach of Black teachers who took a non-traditional pathway to teaching. This paper explores the pedagogical philosophies and

classroom practices of Black lateral-entry STEM teachers. We analyzed data from interviews with middle-grades STEM teachers across a large urban district in the U.S. South. Results indicate that lateral-entry Black teachers take a re-humanizing approach with their minority students, enacted through specific intentional practices in the classroom, which can be understood through the theoretical lens of Anti-Blackness.

Learning to teach students science in anti-racist Ways: Self-reflection, curricular planning, and interactions

Kathleen Schenkel*, San Diego State University, USA
Lucyann Atkins, San Diego State University, USA

ABSTRACT
Supporting elementary teacher candidates to both conceptualize and enact science teaching in racially-just ways is a matter of justice. The utilization of anti-racist teaching strategies matters in assisting future science teachers to teach in ways that redress how science has been used to perpetuate white supremacy. Across three elementary science methods courses (61 participants), we investigated, 1) In what ways, if at all do teacher candidates incorporate anti-racist strategies into their conceptualizations of justice-oriented science teaching? and 2) In what ways, if at all, do teacher candidates plan to enact their conceptualizations of justice-oriented science teaching? Guided by a critical sociocultural theory of learning, data was generated from the teacher candidates' reflections, teaching analysis, and curricular design work. Our findings are: 1) Teacher candidates' conceptualization of justice-oriented science teaching occurred at three different levels: self-reflective, curricular planning, and interactional level. and 2) Teachers were most explicit about addressing racism at the self-reflective level compared to the curricular and interactional level. The findings of this study highlight the need to support teacher candidates learning to become more explicitly anti-racist at the critical curricular planning and interactional levels.

Biking to Uncover Science in Urban Communities: Pre-service Science Teachers' Critical Conscientization of Science-Community

Noemi Waight*, University at Buffalo, USA
Jennifer Tripp*, Buffalo Public Schools, USA
Ryan Rish, University at Buffalo, USA
Monica Miles, Teachers College, USA
Kellyann Ramdath*, University at Buffalo, USA
Sarah Robert, University at Buffalo, USA
Seamus Gallivan, Slow Roll Buffalo, USA

ABSTRACT
This study focused on the community and its resources as the lab, and focused on the experiences and reflections of PSTs as they cycled through an urban, segregated city, to examine science phenomena and understand the cultural and historical significance of urban African American, LatinX, and immigrant communities. Specifically, this study documented PSTs' experiences and their reflections as they (a) identified science and associated resources in the community, (b) used the NYSSLS Regents curriculum to guide what science can be

uncovered in these spaces, (c) engaged what they know about the history and culture of these communities where they and their prospective students live, and, (d) deepened critical consciousness. The findings revealed an important shift, a sense of "seeing" and critical exposure that transformed PSTs awareness of science teaching-learning-community connections, and equity and social justice with pre and post bike ride reflections. This study has implications for understanding community-based, historical, and cultural science teaching and learning, engendering democratic mobility across boundaries to defy access to spaces and places, developing critical conscientization of communities as assets, and as a model for transforming science teacher education.

"A Good Stepping Stone": How Novice Teachers Navigate Tensions While Moving Towards Equitable Field-Based Education

Alexandra Race*, University of California, Santa Cruz, USA
Doris Ash, University of California, Santa Cruz, USA

ABSTRACT
This research explores how teachers who participated in a pre-service professional development program preparing them to teach equitable field-based education (EFBE) in their future classrooms took up the goal of EFBE in their current teaching practice. EFBE is an expansive space where equity and field-based pedagogy are hybridized by educators to move towards practice that is student-centered, NGSS-aligned, based in common experience, supports critical science agency, and incorporates social/environmental/racial justice and historical perspectives. Using a conceptual framework called critical ethnographic CHAT (CE-CHAT), the study examined the categories of tools, object, community, etc. across systems, dwelling in the areas of disjunction, such as mismatches between teachers' goals and their schools' goals, to potentially find pathways and overlaps in moves toward EFBE in theory and practice. The findings presented in this paper will highlight tensions experienced by teachers as they moved towards EFBE in their teaching practice and will explore a path towards EFBE through critical hope (Friere,1994; Duncan-Andrade, 2009).

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set: Extended Reality in Teaching and Learning
4/18/23, 15:00-16:30, PDR 2 (L3)

The Food-Energy-Water Nexus: Using [the tool] to Support Undergraduate Students' Learning about Complex Socio-Hydrologic Issues

Silvia-Jessica Mostacedo-Marasovic*, University of Texas at Arlington, USA
Holly White, University of Maine, USA
Cory Forbes, University of Texas at Arlington, USA

ABSTRACT
The Food-Energy-Water (FEW) Nexus comprehends interactions between water, energy, and food systems, where water allocation decisions constitute complex socio-hydrologic issues (SHIs). Undergraduate students need to develop skills to understand and make effective decisions about the FEW-Nexus. We implemented a comprehensive curriculum where undergraduate students engaged in decision-making around a FEW-Nexus challenge using an online water visualization tool – [Tool]. We ask: i) to what extent is a decision-making task supporting students' problem-solving outcomes about a FEW Nexus issue? ii) what areas in the decision-making process were students able to engage in most effectively? and iii) to what extent do students' systems thinking skills support their overall problem-solving outcomes? We used a mixed-methods approach. We analyzed a four-part assignment from N = 99 students using non-parametric Friedman tests to compare between each component of the decision-making and systems thinking outcomes. We complemented the results with interviews from n = 13 students. Results suggest that [Tool] allowed students to gain a critical understanding about the different uses of water and the extent of their impacts in a selected region. Students may need additional support to better frame the decision-making problem. The study can help inform students' use of real data to address SHIs.

Elementary Preservice Teachers Learn Cardiac Form and Function with 3-D, Haptically-Enabled, Virtual Reality

Darby Drageset*, University of Florida, USA
Kent Crippen*, University of Florida, USA
Jeungtae Eom, University of Florida, USA
Hada Herring, University of Florida, USA
Niki Koukoulidis, University of Florida, USA

ABSTRACT
Utilizing the framework of systematic replication, we conducted a distal conceptual replication of a published intervention study that was originally completed with sixth and ninth-grade participants in order to better understand the critical features and transferability to preservice elementary teachers. The intervention involved learning about cardiac structure and function in virtual reality (VR) with 3-D representations and haptic-enabled feedback. We intentionally manipulated the setting, duration, and arrangement of participants, but used the same methodology. Results support learning about heart anatomy, function, and blood flow ($p<0.001$), with an increase of 13.8% and a large effect size ($d=1.26$). A similar change was documented for sixth-grade students (13.3%), but was much less than the 26.6% change for ninth-grade students, suggesting a conditional effect for prior knowledge since the content is a seventh-grade standard. These results are further illustrated with an analysis of drawings and tracings. To fully realize the potential of VR for science education, effective models are needed and this study is a step in that direction. This presentation will be of relevance to members engaged in elementary science education and/or those using design-based research for transformative learning environments.

Home Far Away: Exploring Virtual Field Trips as a Tool for Social Justice-Based Science Education

Bryan Brown*, Stanford University, USA
Kathryn Ribay*, San Jose State University, USA
Kendra Sobomehin*, Stanford University, USA
Tamara Sobomehin*, Stanford University, USA

ABSTRACT
Distance teaching led science teachers to adopt technology to support their learning goals. Virtual Reality (VR) emerged as an instrument to provide students with valuable learning experiences. We examined students' responses to using Virtual Field Trips (VFT) to "visit" African nations engaged in climate change reform. Through n= 58 post-interviews, we explored students' perspectives on learning, explored how VR impacted their climate change knowledge, and examined students' thoughts on the value to local communities. Students enjoyed the immersion in virtual field trips, lauded its impact on learning, and drew connections to how what they learned could translate to community action at home. This study suggests that immersive experiences can support learning goals but can also generate a "third-space" to connect with students' homes.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set: Developing Teachers' NOS Views
4/18/23, 15:00-16:30, Salon C7-8 (LL)

Preservice SPED Teachers' Nature of Science Conceptions and Lesson Planning

Mila Rosa Carden*, University of North Texas, USA
Bridget Mulvey, Kent State University, USA
Laura Corr, Arizona State University, USA

ABSTRACT
Very little research examines the critical intersection between science and special education (SPED). This investigation addresses this gap in the research by focusing on preservice SPED teachers' nature of science (NOS) and how they plan their NOS instruction. Participants are 10 preservice SPED teachers in a science methods course with concentrations in mild to moderate intellectual disabilities (8) and deaf education (2). A conceptual change framework guided the development of the study's NOS intervention. Data sources included participants' pre- and post-course Students Understanding of Science and Scientific Inquiry (SUSSI) responses and lesson plans. SUSSI responses were analyzed to categorize participants' NOS conceptions, whether informed, has merit or naïve for each NOS aspect. Lesson plans were assessed for NOS integration using Herman et al's (2013) protocol. Results indicated that participants' NOS conceptions largely improved post-course particularly in observations and inference, tentativeness, and creativity. All participants in the present study designed inquiry-based lessons but most (80%) implicitly included NOS in their lesson plans. This is a relatively

strong outcome, given that NOS was not a required component of the lesson plans. Future research will examine preservice SPED teachers' science instruction and NOS learning outcomes of students with special educational needs.

Exploring the view of NOS and PCK of NOS in a group of biology teachers.

Carolina Parraguez*, Universidad Catolica de Valparaiso, Chile
Paola Nuñez, Universidad Catolica de Valparaiso, Chile
Hernan Cofre, Universidad Catolica de Valparaiso, Chile

ABSTRACT

This study describes and evaluates the impact of a professional development program (PDP) intervention on in-service biology teachers' understanding of NOS and PCK of NOS. The research includes a sample of 12 teachers from different regions of Chile and with different years of experience. Data collection was done through a modification of the VNOS-D+ questionnaire that included two extra questions from the VASI questionnaire and the use of the semi-structured interview Content Representation (CoRe). The research design is single group pretest/posttest, conducting 2 analyses: 1) Change in the View about NOS and 2) The change of teachers' NOS PCK. The results show that both the view about NOS and the PCK of teachers increase after the PDP. For the view of NOS, the characteristics with the greatest change are sociocultural influence, difference between theory and law and there is no single scientific method. As for PCK, the aspects of the components on knowledge of strategies increase, being history of science and argumentation the most declared, and the alternative conceptions of students about "The scientific method" and that science does not change the learning aspect more mentioned.

Leveraging a History and Philosophy of Science Course to Develop PCK for Teaching NOS

Khadija Fouad*, Appalachian State University, USA
Alan King, Appalachian State University, USA
Matthew Lance, Appalachian State University, USA

ABSTRACT

A history and philosophy of science (HPS) course for preservice secondary teachers used history of science (HOS) to improve nature of science (NOS) understandings, improve argumentation skills, develop PCK for teaching NOS, and expand conceptions of the practice and origins of scientific thought by examining the work in pre-Enlightenment, non-Western scientific traditions. Students prepared for explicit, reflective discussions of NOS and developed their argumentation skills by writing statements of critical significance and a historiographic essay (Dass, 2005). The essays explored HOS from non-Western cultures and how these contribute to or contrast from the Western science. Methods using HOS to teach NOS based on Rudge and Howe's (2009) model using HOS instrumentally for teaching NOS, García-Carmona and Acevedo-Díaz's (2016) methodology for teaching NOS with newspaper articles of current scientific events, and Cavicchi's (2014) open-ended historical investigations were modeled for students. Activities for the development of PCK for using HOS to teach NOS and to improve understandings of the difference and relationship between scientific theories and laws were included. Most prospective teachers improved both NOS understandings and

argumentation skills during the course. Some designed and implemented lessons using HOS to teach NOS in their own high school classrooms.

Pre-Service Teachers' Scientific Content Knowledge and Nature of Science Views after a Socioscientific Issues-based Unit

Savannah Graham*, Texas Christian University, USA
Hayat Hokayem, Texas Christian University, USA

ABSTRACT

This study investigates undergraduate pre-service teachers' knowledge about COVID-19 and nature of science aspects after the implementation of a socioscientific issues-based unit about the COVID-19 pandemic. Students enrolled in a science content for elementary teachers' course at a large, private university in the Southern part of the USA participated in the study. The COVID-19 unit began with scientific content about viruses, bacteria, and COVID-19 before moving into the societal aspects of the pandemic with the spread and transmission of disease and nature of science. The data sources consisted of pre/post-semi-structured interviews and pre/post-written assessments. Due to a lack of content responses on written assessments, we could not obtain common patterns or results other than a few examples of content knowledge gains with specific participants from before and after the unit. After the unit, post-interviews showed students primarily held transitional views of each nature of science aspect (tentativeness, process, society, creativity). However, students had informed views of tentativeness and process of science and naïve views of society and creativity in science. Finally, we discuss the implications of these results for future pre-service teacher training with nature of science in the context of socioscientific issues-based instruction.

Concurrent Session 2
4/18/23, 16:45-18:15

Contemporary Methods RIG
Sponsored Session: Measurement, Methodologies, and Methods in Science Education Research
4/18/23, 16:45-18:15, Salon A5 (LL)

Measurement, Methodologies, and Methods in Science Education Research

ORGANIZERS
Francesca Williamson, Indiana University School of Medicine, USA
Brock Couch, University of New Hampshire, USA
Robert Talbot, University of Colorado, Denver, USA
Stanley Lo, University of California, San Diego, USA
Glenn Dolphin, University of Calgary, Canada
Joseph Taylor, University of Colorado, Colorado Springs, USA

PANELISTS
Nancy Staus, Oregon State University, USA
Samia Khan, University of British Columbia, Canada
Ben Van Dusen, Iowa State University, USA
Rou-Jia Sung, Carleton College, USA
Tiffany-Rose Sikorski, The George Washington University, USA
Megan Ennes, University of Florida, USA
Haider Ali Bhatti, University of California, Berkeley, USA
John Russell, EL Education, USA
Sophia Jeong, The Ohio State University, USA
Kathryn M. Bateman, The Pennsylvania State University, USA

ABSTRACT
This symposium aims to promote innovative and rigorous research practices in science education research. A collection of 10 selected papers, with 33 authors from 25 institutions, will discuss philosophical, theoretical, methodological, ethical, and practical considerations of designing and implementing various approaches to research in science education and related research areas. The session will include individual paper presentations and follow-up roundtables for participants to continue discussions about methodological practice. Participants will also have an opportunity to express interest in creating formal spaces for methodological inquiry within the NARST community.

The Case for Using Person-Centered Analytical Approaches in STEM Education Research
Nancy Staus, Oregon State University
Case Study in Science Education Research

Samia Khan, University of British Columbia, Canada
Comparison of MAIHDA and Traditional Multilevel Models for Modeling Intersectionality: A Simulation Study
Ben Van Dusen, Iowa State University; **Jayson Nissen**, Nissen Education Research & Design; **Heidi Cian**, Florida International University; **Lucy Arellano**,Texas Tech University; **Adrienne Woods**, SRI international
Duoethnography as a Methodology for Examining Faculty Professional Identities
Rou-Jia Sung, Carleton College; **Emily A. Holt**, University of Northern Colorado; **Stanley Lo**, University of California San Diego
Epistemic Frame Shifts to Analyze Coherence from the Learners" Perspective
Tiffany-Rose Sikorski, The George Washington University
New Methods for Assessing Factors that Influence Science Career Aspirations for Youth and Their Parents
Megan Ennes, University of Florida; **Gail Jones**, North Carolina State University; **Katherine Chesnutt**, Appalachian State University; **Emily Cayton**, Campbell University; **Daniel Macher**, University of Graz; **Manuela Paechter**, University of Graz
A Scientific Approach to Assessment: Rasch Measurement and the Four Building Blocks
Haider Ali Bhatti, University of California, Berkeley; **Smriti Mehta**, University of California, Berkeley; **Rebecca McNeil**, University of California, Berkeley; **Shih-Ying Yao**, Singapore University of Social Sciences; **Mark Wilson**, University of California, Berkeley
Strengthening Case Study Selection through Social Network Analysis
John Russell, EL Education; **Todd Campbell**, University of Connecticut; **Byung-Yeol Park**, University of Connecticut; **Emily Lisy**, University of Connecticut; **Yue Bai**, University of Connecticut
Reimagining Methods in Science Education Research through the Lens of Rhizomatics
Sophia Jeong, The Ohio State University; **Elena H. Silverman**, Indiana University-Purdue University Indianapolis; **Saralyn M. McKinnon-Crowley**, Georgia Institute of Technology; **M. Nickie Coomer**, Colorado College
Wickedly: Wicked Problems, Transdisciplinarity, and Dialogic Reflexivity
Kathryn M. Bateman, The Pennsylvania State University; **Brandon Sherman**, Indiana University-Purdue University Indianapolis

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Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set: Conceptual Understandings in Biological Contexts
4/18/23, 16:45-18:15, Salon C1-2 (LL)

Influence of Self-Assessment and Conditional Metaconceptual Knowledge on Students' Conceptual Understanding of Evolution
Tim Hartelt*, University of Kassel, Germany
Helge Martens, University of Kassel, Germany

ABSTRACT
Teleological, anthropomorphic, and essentialist conceptions often prove helpful in everyday life, while simultaneously being problematic in scientific contexts. Nonetheless, students often have coexisting alternative/everyday and scientific conceptions even post-instruction on scientific topics such as evolution. As potential approaches to reduce alternative conceptions, we investigated the effect of (a) a criteria-based self-assessment of one's own preconceptions and (b) instruction on conditional metaconceptual knowledge (metacognitive knowledge about when and in which contexts specific concepts are appropriate or not) on students' conceptual knowledge about evolution as well as on their ability to identify inappropriate teleological, anthropomorphic, and essentialist phrasings. To this end, we conducted an experimental intervention study with a pre-post-follow-up-test design with five invention groups in upper-level biology classes. Students who received intervention on conditional metaconceptual knowledge were better at identifying inappropriate phrasings in the post-test, while the intervention on self-assessment had no effect. Students who received both interventions used more key concepts and fewer alternative conceptions when explaining evolution in the post-test than students who received no intervention. The results show that students can be taught to become aware of the differences between everyday and scientific conceptions and can learn to regulate their everyday conceptions in a scientific context.

Exploring how students evaluate explanations about biological phenomena in different grades of elementary school

Yael Shtechman, Department of Science Teaching, Weizmann Institute of Science, Israel
Marida Ergazaki, Department of Educational Sciences and Early Childhood Education, University of Patras, Greece
Michal Haskel-Ittah*, Department of Science Teaching, Weizmann Institute of Science, Israel

ABSTRACT
The contribution of mechanistic reasoning to the ability to understand and evaluate scientific information was acknowledged in science education research. However, the literature in science education offers conflicting views about elementary school children's ability to reason about mechanisms. It was suggested that merely asking students to explain phenomena does not provide enough guidance for choosing or providing a mechanistic explanation. Thus, an exploration of how students choose explanations once the task's goal is to explain how biological phenomena occur is needed. In this research, we interviewed 52 elementary-school children from 2nd to 6th grade. In those interviews, children were asked to evaluate four explanations (teleological, circular, and two mechanistic explanations) for several biological phenomena. We found that children can distinguish between different types of explanations, and evaluate these explanations using the knowledge they have about the biological world as well as knowledge about the causal structure of explanations. Overall, our data seem to suggest that children as early as second grade can begin thinking about mechanisms and realize their explanatory power. This calls for explicit discussion of types of explanations at the elementary school level.

Concurrent Session 2, 4/18/23, 16:45-18:15

Benefits of learning about the threshold concepts of randomness and probability in biological contexts

Helena Aptyka*, Institute for Biology Education, Faculty of Mathematics and Natural Sciences, University of Cologne, Germany
Daniela Fiedler, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Jörg Großschedl, Institute for Biology Education, Faculty of Mathematics and Natural Sciences, University of Cologne, Germany

ABSTRACT
Knowledge about evolutionary processes is paramount to students' fundamental education because evolution unifies all areas of biology. However, students' conceptualizations of evolution frequently hold misconceptions. Explanatory approaches regarding the persistence of misconceptions suggest that misconceptions are related to insufficient knowledge about threshold concepts. Additionally, studies indicate that knowledge about the threshold concepts of randomness and probability in mathematical or biological contexts allows for a deeper understanding of evolution. As empirical research is scarce, this study examines students' use of key concepts, misconceptions, and threshold concepts about natural selection after learning about randomness and probability in biological or mathematical contexts and subsequent learning about natural selection. We conducted an experimental intervention study and recruited N = 128 secondary school students. The results reveal that threshold concepts correlate positively with key concepts and negatively with misconceptions. Notably, randomness and probability are negatively associated with teleological ideas. Moreover, students used more key concepts after learning about randomness and probability in biological and mathematical contexts and more threshold concepts after learning about randomness and probability in biological contexts than the control group. In conclusion, including threshold concepts in learning offers a powerful learning approach and unlocks novel perspectives when taught explicitly and interdisciplinarily.

Experimentally Comparing Student Interest in, Engagement in, and Comprehension of Expository and Narrative Biology Videos.

Matthew Kloser*, University of Notre Dame, USA
Michael Szopiak, University of Notre Dame, USA
Catherine Wagner*, University of Notre Dame, USA

ABSTRACT
Secondary science learning environments commonly utilize texts, such as videos, yet most are expository in nature. Theoretically, narrative texts may better promote interest in and the comprehension of science ideas, but often at the expense of efficiency and clarity of main ideas. This experimental study explores the outcomes from high school students watching biology videos distinguished by genre to answer: (1) What within-subject differences exist for students' interest and engagement when watching expository versus narrative videos?; (2) What between-subject differences exist in students' comprehension of science ideas when watching expository or narrative biology videos? Forty high school students were randomly assigned two videos, one of each genre, using a counter-balanced and crossed design. Participants completed a battery of questions, including self-reported engagement and interest

measures and multiple-choice comprehension questions drawn from the videos. Findings show that students found the narrative videos more engaging and interesting without sacrificing comprehension. There was no difference between comprehension of the two videos although an interaction effect was found between number of biology courses taken and genre. These findings point to the potential for expanding the types of genres used in high school biology learning.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Context and Learning Science
4/18/23, 16:45-18:15, Salon C3-4 (LL)

Ties That Bind: Identifying Influential Scholarship in Contextualized Science Learning Research Through Bibliometric Network Analysis

Michael Giamellaro*, Oregon State University, USA

ABSTRACT
Science education regularly sees new innovations that are resisted due to "innovation fatigue". Couching new ideas as variations of known concepts may decrease resistance and ease teacher learning of new approaches. Contextualization, connecting science content to authentic contexts, is one theme many recent innovations are founded on. This bibliometric network analysis of 935 academic papers describes the landscape of contextualized science education research. Bibliometrics uses citation patterns in a field to identify social network structures that generate and evolve groups of ideas. Thirteen clusters of ideas that have evolved within the landscape of contextualized science learning are identified and described. The focus is on individual documents that play an outsized role in representing the network parts or bridging them, as identified through metrics ofnetwork centrality. Findings can be used to identify intellectual pathways between clusters and to magnify similar research across clusters. The methods can be used to describe other intellectual landscapes in science education.

The Importance of Classroom Emotional Climate in STEM Education Research

Felicity McLure*, Charles Darwin University, Australia
Barry Fraser, Curtin University, Australia
Rekha Koul, Curtin University, Australia

ABSTRACT
Over the past two decades integrated STEM (iSTEM) projects have been introduced into Science classes in order to help students relate their Science skills and content learning with learning in Mathematics, Engineering and Technology to solving real-world problems. One of the desired outcomes was to engage student interest in pursuing STEM subjects in senior high school and at university. A previously neglected factor that influences students' engagement with and interest in pursuing a learning area is the classroom emotional climate (CEC). This presentation reports on the development and validation of an instrument to measure students' perceptions of CEC when participating in iSTEM projects. The interrelationships between the

iSTEM learning environment, the influence of teacher-student interpersonal relationships and students' interest in pursuing STEM subjects and the effect of gender on these relationships were examined in a sample of 698 students participating in STEM projects in 57 classes in 20 schools. The findings suggest significantly different ways in which females and males perceive the iSTEM learning environment, and suggest that females need support from their teachers, particularly in short-term iSTEM projects in Science classes.

Ways to Learning Science are Undergoing Mutation: Would the Culturo-Techno-Contextual Approach be an Effective Variant?

Adekunle Oladejo*, 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
Juma Shabani, University of Burundi, Burundi
Yinka Ogunlade, Ekiti State University, Nigeria
Bugoma Suwadu, University of Burundi, Burundi
Ibukunolu Ademola, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Deborah Agbanimu, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Esther Peter, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Franklin Onowugbeda, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Olasunkanmi Gbeleyi, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria

ABSTRACT
As the quest for better ways to present science to the new generation of students continues to occupy the thoughts of science educators across the globe, so will new approaches such as the Culturo-Techno-Contextual Approach (CTCA) continue to emerge in response to our needs. This study explores the potency of CTCA in breaking the barriers to meaningful learning of electrochemistry. The explanatory sequential design was employed. Total of 141 secondary schools (II) students from two purposively selected schools in Lagos State education district V participated in the study. The electrochemistry achievement test which had a reliability coefficient of 0.78 was the instrument used to collect the quantitative data. Treatment lasted five weeks after the conduct of the pretest, the experimental group was taught using CTCA and the control group was taught using the traditional lecture method. Four weeks after the posttest, the retention test was conducted. One-way ANCOVA was used to analyse the data. The experimental group out-performed the control group, but CTCA had no differential impact on students in the experimental group based on gender. Within the limitations of the study, we concluded that CTCA is capable of promoting meaningful learning in chemistry. Implications of the study were highlighted.

Interest-Based Differentiated Instruction Through Varied Contextual Tasks in Chemistry Education

Fabien Gueth*, University of Duisburg-Essen, Germany
Helena van Vorst, University of Duisburg-Essen, Germany

ABSTRACT
Differentiated instruction can be used to address the varying learning needs of students in the classroom. While performance-based differentiation has been sufficiently studied, research approaches to investigate interest-based differentiation are missing so far. Previous research from context-based learning suggests that different types of students choose tasks with different context characteristics and that varied contextual tasks are therefore suitable for interest-based differentiation. In this regard, it is unclear whether the choice of a contextual task or the fit between context and student has an impact on students' learning outcomes.
To address this research gap, an experimental study was conducted with 219 third-year chemistry learners from secondary schools. The study compared three groups that were varied in terms of context choice and the fit between context and student. All groups worked on three sequential contextual tasks with different characteristics. The results show that the choice and no choice & match condition show higher situational interest in task processing than the no choice & no match condition. However, there are no differences between the choice and no choice & match condition. Consequently, the fit between context and student, rather than choice, is especially critical to the effectiveness of interest-based differentiation in chemistry education.

Strand 3: Science Teaching - Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set: Modeling in Elementary Science Classrooms and Informal Science
4/18/23, 16:45-18:15, PDR 2 (L3)

Kindergarten Students' Constructed Models as Tools for Modeling-Based Investigations and Learning

Loucas Louca*, European University Cyprus, Cyprus

ABSTRACT
A growing body of evidence has highlighted the added value of Modeling-based Learning (MbL) in science when incorporated into early grades. This descriptive case study seeks to describe the ways two groups of kindergarten children engaged in MbL taught by 2 teachers participating in a professional development program of kindergarten MbL in science. The study specifically focuses on the ways that these groups of children used their constructed models as tools for further investigation and learning. Findings across the two cases suggest that participating kindergarten children successfully engaged in authentic MbL activities, while they (a) were able to use their own models as tools for further investigations of and learning about the phenomenon; and (b) have modeling resources that can activate and use in order to

consider and use their own constructed models as theoretical structures that can be applied in a (new) phenomenon to explain new (parts of the) phenomena. I use this evidence to highlight the dynamic nature of the children's models when used as references in children modeling conversations. Lastly, I discuss implications for how teachers would find it more productive to view and use these children's resources in the ways children use their own-constructed models.

Modeling to (Re)think Scientific Language: A Case of Preservice Elementary Teachers Building Knowledge

Ayca Fackler*, University of Georgia, USA

ABSTRACT

Knowledge-building in science classrooms requires learners to use a variety of linguistic resources in addition to scientific language. Multimodal modeling practices have the potential to enhance learners' knowledge-building experience through constant shifts between scientific and everyday language. Grounded in the Semantics dimension of the Legitimation Code Theory, this case study examined how multimodal modeling practices can help learners switch between scientific and everyday language by leveraging their linguistic resources in science learning. Data sources were audio and video recordings that captured the modeling instruction and interviews along with artifacts. A Multimodal Interaction Analysis suggested that multimodal modeling practices encouraged learners to switch between everyday and scientific words or phrases by facilitating the development of a shared, intermediate language.

Elementary Teachers as Collaborators: Developing Educative Supports for Citizen Science Projects

Sarah Carrier*, North Carolina State University, USA
Jill McGowan, North Carolina State University, USA
Lindsey Sachs*, Horizon Research, Inc., USA
Meredith Hayes, Horizon Research, Inc., USA
P. Smith*, Horizon Research, Inc., USA

ABSTRACT

Science education is a critical component of a full education (Appleton,2013), beginning in primary grades. In recent decades, research has identified young learners' rich knowledge of the natural world and their potential to connect with sophisticated science ideas (NASEM, 2022). Elementary teachers face many challenges for including reform-based science instruction in their classrooms. In an effort to address these challenges, some teachers have chosen to enhance their science instruction by introducing students to citizen science (CS) projects. Unfortunately, few CS projects offer substantial guidance for teachers seeking to implement the projects for instructional purposes, placing a heavy burden on teacher learning. One way to remove this burden on teachers is the development of educative curriculum materials (Davis et al., 2017). Our larger study's research examines how teachers use instructional support materials for two citizen science projects. In this initial research, we highlight our important collaborations with teachers and our learning from teachers during the

development and revision of our educative support materials for CS. These data demonstrate the importance of incorporating teacher voices in reform efforts.

The space between: Teacher perceptions of an interformal elementary science education program

Rachel Stronach*, University of Massachusetts Dartmouth, USA
Hamza Malik*, University of Massachusetts Dartmouth, USA
Stephen Witzig*, University of Massachusetts Dartmouth, USA

ABSTRACT
To realize a STEM Learning Ecosystem (NRC, 2015) all collaborations around science learning should be engaged. This study uncovers teacher perceptions of a substantial, long-term, formal/informal elementary science program partnership. Through participant interviews with three elementary teachers and our case study analysis, we assert that for more significant formal/informal science education partnerships to succeed, teachers must perceive the partnership to be beneficial to them in their teaching and to their students' science learning. We assert teachers want to know that precious instructional time is spent on programs related to or even integrated into their curriculum. We discovered teachers perceive their students formed a connection to a local environmental organization through the program partnership. This study brings to light an area that is not discussed in the literature, the sustained, long-term blending of formal/informal into a new space in the elementary classroom. A space where the benefits of informal science education meld and mix within the structure of a formal classroom as the program is fully integrated into the science curriculum and has been for over 15 years. We define this space as interformal. We look forward to the discussions this paper sparks at the conference.

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

SC-Organized Paper Set: Teacher Professional Identities and Reflective Teaching

4/18/23, 16:45-18:15, Blvd A (L2)

From bench scientist to middle school science educator: Lessons learned from Black STEM PhD holders

Monica Miles*, Teachers College, Columbia University, USA
Patricia Buenrostro*, Lake Forest College, USA

ABSTRACT
Next Generation Science Standards' goal is to better prepare students for jobs demanding STEM expertise. National leaders have called on professionals in STEM fields to assist in enhancing STEM literacy and contribute to improving the quality of STEM education at the K-12 level. It has been proposed that scientist-teacher collaborations may be an effective way to facilitate an understanding of scientific inquiry. The purpose of this narrative analysis is to underscore the ways in which Black STEM-focused post-doctoral fellows experienced

transitioning from research lab scientists to science educators in K-12 settings. The focal participants reported key obstacles in their efficacy to teach K-12 populations implicating the need to have focused professional development opportunities on pedagogy and collaboration.

Understanding asset-based pedagogies through funds of knowledge and identity: A case for rural science teaching

Khanh Tran*, Purdue University, USA
Selcen Guzey*, Purdue University, USA

ABSTRACT
In the United States, K-12 classrooms are increasingly becoming more diverse with students bringing rich knowledge and experiences from their homes and communities. Of those classrooms, rural students make up approximately one-third of the overall population in the U.S.; yet, despite the increasing number of diverse students in all areas, much of the attention relating to equity and access to quality science education has focused on urban and inner-city communities. For this case study, we worked with a rural middle school science teacher to understand how his prior lived experiences propelled him to utilize asset-based approaches. Drawing on interviews, videotape recordings, and journal reflections, we used a constant comparative analysis method to identify the teacher's funds of knowledge and identity and constantly compare how they informed his use of asset-based pedagogies. We found that his lived experience informed his teaching in two ways: (1) accumulated intergenerational cultural wealth informing his use of culturally responsive teaching and (2) accumulated intragenerational cultural wealth informing his use of culturally relevant teaching. We also found that the teacher used his generational cultural wealth as a catalyst to agentic student-focus teaching after he became more aware of his lived experiences and student backgrounds.

Inquiry (co)Learning: Science teachers' exemplary inquiry-based teaching

Shani Zur*, Technion, Israel
Tali Tal, Technion, Israel

ABSTRACT
Inquiry-based learning is a well-known approach in science education. However, evidence suggests that often inquiry is taught in a teacher-initiated manner. In this study, we examined exemplary inquiry-based learning to unfold teachers' views, choices, and actions that foster exemplary inquiry-based learning. We implemented an interpretive-qualitative phenomenology approach and focused on the question: What elements, according to the teachers' views, foster their exemplary inquiry-based teaching? Based on recommendations, we carried out interviews with 12 science teachers who implemented exemplary inquiry-based learning in their classes. we also collected relevant texts such as blogs, articles written by teachers, and teachers' inquiry plans. We found that teachers implemented a co-learning strategy. They shifted away from the position of being the source of knowledge and acted as a co-learner. Moreover, we found that co-learning contributed to the success of inquiry learning on two levels (1) by creating inquiry driven culture in class and (2) by incorporating inquiry-driven practices as part of their teaching. Both levels were fostered by a set of behaviors and actions in different contexts. Our findings highlight the importance of inquiry-driven culture and its

features and offers a few emphases that can be used in science classes that we named inquiry-driven practices.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Symposium: Equity Considerations for Post-Secondary STEM Education
4/18/23, 16:45-18:15, Salon C5-6 (LL)

Equity Considerations for Post-Secondary STEM Education
Jennifer Adams*, University of Calgary, Canada
Sarah El Halwany*, University of Calgary, Canada
Kristal Turner, University of Calgary, Canada
Nadia Qureshi, University of Toronto, Canada
Takeshia Pierre*, University of Florida, USA
Rose Pringle, University of Florida, USA
Paulette Vincent-Ruz, New Mexico State University, USA
Katy Hosbein, Middle Tennessee State University, USA
Lucy Avraamidou, University of Groningen, Netherlands
Phillip Boda, University of Illinois Chicago, USA
Geraldine Cochrane, Rutgers, USA

ABSTRACT
Post-secondary STEM education is a ripe context for equity considerations to "expose dominant assumptions about what counts as science and who counts in science" (Kayumova & Dou, 2022, p. 11) with direct implications for retention and success in STEM fields. This session, brings together researchers and practitioners whose expertise in post-secondary STEM education affords them with a nuanced lens into possibilities and challenges faced by Black, racialized and undeserved students as they transition and/or are embedded in postsecondary contexts. Presenters reflect on equity considerations for Discipline-based Education Research (DBER), an encompassing field that examines the intersection between fields of STEM with education and learning research. They bring important insights that draw from critical race theory, disability studies, emotions and affect and intersectionality while spanning qualitative, creative and quantitative research approaches that attend to the various contexts where post-secondary aged students encounter STEM education.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Formal and informal science curriculum in pre-service science teacher education
4/18/23, 16:45-18:15, Salon A2 (LL)

Integrating non-formal activities in a formal pre-service science teacher education program
Isabel Borges*, Institute of Education - University of Lisbon, Portugal

Isabel Chagas, Institute of Education - University of Lisbon, Portugal

ABSTRACT
The purpose of this paper is to present an appraisal of a Didactics of Biology and Geology course with non-formal STEM experiences and co-teaching with a non-formal educator, in the learning of pre-service science teachers (PSTs), and how they integrate the non-formal experiences into the design of learning scenarios.The participants were 13 PSTs (7 females and 6 males): 2 PSTs from Guinea Bissau and 11 native Europeans enrolled in a Master Biology and Geology Teaching program offered by a European University. A qualitative and interpretive approach was followed. Data were collected through participant observation, content analysis of the pre-service science teachers' individual written reports, and their proposal of learning scenarios. The results showed the value of this formative approach, concerning the learning opportunities it offers related to the integration of the curriculum Biology and Geology content when adopting a non-formal STEM proposal, and when creating brand new proposals. In general, the participants produced consistent inquiry-based innovative teaching proposals to teach their subjects (Biology and Geology) integrated into a STEM perspective.The use of non-formal approaches and resources enriches pre-service teachers' learning about the nature of science, inquiry-based science learning, and STEM teaching.

Recomposing the Practice of Teaching Elementary Science
Marti Canipe*, Northern Arizona University, USA

ABSTRACT
Elementary teacher educators endeavor to prepare prospective elementary teachers to teach science in ways which best support student learning. One framework which has been used in many teacher preparation programs consists of three-parts: representation, decomposition, and approximations of practice. In this study I examined the science teaching practice of three student teachers enrolled in the same teacher education program to understand how they enacted teaching practices from their teacher education coursework. Findings showed that each student teacher adopted a different, singular practice as their primary guide for teaching science rather than a more integrated approach. This suggests that a more explicit focus on recomposition of practice is a necessary part of teacher education.

Differential effects of internal and external feedback on different types of teachers' professional knowledge
Büsra Tonyali*, University of Duisburg-Essen, Germany
Mathias Ropohl, University of Duisburg-Essen, Germany
Julia Schwanewedel, University of Hamburg, Germany

ABSTRACT
Planning and preparing instructional materials are part of teachers' daily work and can be done in many ways. Especially in science education, instructional materials are characterized by subject-specific representations. As previous research indicates, working with representations is a substantial challenge for pre-service teachers and therefore requires support. In this project, we use the potential of internally and externally provided feedback to address this

challenge. A pre-post intervention study with three intervention groups was carried out as an interactive and online self-learning module. The study involved N= 98 German teacher candidates during the in-service teacher training. Dependent variables are the teacher candidates' content knowledge (CK), pedagogical content knowledge (PCK), and beliefs regarding representations. The test instruments were piloted prior to the intervention with N= 50 Master students and indicate satisfactory characteristics. The quantitative results show that the group working only with internal feedback gains PCK. In contrast, the group receiving internal and external feedback gains CK significantly. Both results indicate that different types of feedback can be used to support different teachers' knowledge types. The beliefs did not change through feedback in any group.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Exploring STEM Research in curriculum and identity development at Teacher Preparation level
4/18/23, 16:45-18:15, Waldorf (L3)

An Overview of STEM in Bachelor of Education Programs in Canada

G. Michael Bowen*, Mount Saint Vincent University, Canada
Dawn Wiseman, Bishop's University, Canada
Marie-Claire Shanahan, University of Calgary, Canada
Samia Khan, University of British Columbia, Canada
Allison Gonsalves, McGill University, Canada
Pratim Sengupta, University of Calgary, Canada
Wendy Simms, Vancouver Island University, Canada
Eva Knoll, Université du Québec à Montréal, Canada
Ashley Carter, Mount Saint Vincent University, Canada

ABSTRACT
Since emerging as a concept in the 1990's STEM and STEM education have really only become an area of broad interest in Canada in the past fifteen years. Given the promotion of STEM in science faculties at universities and associated provincial education programs the question arises as to the degree to which STEM and courses teaching (about) STEM are present in Faculties of Education in Canada. This paper presents data drawn from Canadian Bachelor of Education academic calendars (n=56), Canadian academic conferences where research on STEM in BEd programs would be presented (n=17), and publications from the Council of Ministers of Education to discuss STEM's prevalence. Additionally, four detailed, narrative descriptions of STEM courses at four faculties of education provide examples of the breadth of offerings available in Canadian BEd programs. In summary, there are few courses offered, and even fewer STEM programs, in BEd programs in Canada raising questions about the support offered by them for STEM school initiatives that exist both provincially and federally. Implications of this are discussed.

Concurrent Session 2, 4/18/23, 16:45-18:15

The STEM Problems Distinction Toward STEM Teacher Identity Development of Indonesia Pre-Service Science Teacher

Anjar Utomo*, University of Minnesota, USA
Gillian Roehrig, University of Minnesota, USA

ABSTRACT

Undeniably, the powerful global influence of integrated STEM education has shifted how a science teachers must teach science to their K-12 students. These cultural shifts in science education are complex necessitating that teachers negotiate their identity, new norms, institutions, and processes especially Indonesia that does not have do not have regulations and curricula for integrated STEM education. This issue is due to a lack of a proper context in which it is a fundamental aspect that intermediates both STEM education integration and the development of STEM teacher identity as context provides a place where integrated STEM discourse happens between STEM instructor, teachers, and students. We use literature review approach in order to explore this theoretical paper's question. In conclusion, a context provides spaces (spheres) in a layer where a discourse, such as integrated STEM education implementation in this case, occurs between pre-service science teachers and their instructors in the STEM-related courses. In other words, discourse influences and are influenced by identity development.

The impact of STEM camp on prospective science teachers' identity development

Danielle Dani*, Ohio University, USA
Courtney Koestler, Ohio University, USA
Lizhen Chen, Ohio University, USA
Allyson Hallman Thrasher, Ohio University, USA
Kayla Heacock, Ohio University, USA

ABSTRACT

This study describes the outcomes of an early field clinical experience, STEM Camp, on master's level teacher candidates' developing identity as effective science teachers. Participants are three science teacher candidates who participated in STEM Camp and the linked introductory course focusing on STEM content and practices. Data sources include a pre-camp individual interview, post camp group interview, candidate reflections, and camp debrief notes. Data was analyzed inductively. Findings indicate that teacher candidates began the program with views of science teaching that centered on doing science to understand the world and connecting teaching to students' knowledge and experiences. After STEM Camp, teacher candidates additionally described themselves as orchestrators of the learning environment, investigators of student ideas, and testers of what works as they strive to meet student needs. Findings and factors that lead to them are discussed.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Supporting Beginning through Experienced Science Teachers in Implementing Culturally Relevant Instruction
4/18/23, 16:45-18:15, Salon A3 (LL)

Science Teacher Preparation Through Abolitionist Teaching: A Narrative Inquiry Study

Vanessa Louis, Georgia State University, USA
Natalie King, Georgia State University, USA

ABSTRACT
This narrative inquiry (Clandinin & Connelly, 2004) study leverages abolitionist teaching (Love, 2019) to examine novice science teachers' experiences navigating the first two years of teaching while participating in a federally funded fellowship. Data sources include semi-structured interviews and archival data collected from the teacher preparation courses. Significant findings of this study revealed that (a) the novice science teacher's decision to leave the STEM profession was attributed to a need to provide an equitable education for all students, (b) novice science teacher's experience within the methods course prepared them to deconstruct Love's (2019) educational survival complex within their classroom and school and (c) the fellowship provided a community of learners for the novice science teachers to lean on.

Noyce Scholars Retention and Culturally Competent Teaching Practices

Peter Garik*, Boston University, USA
Donald DeRosa, Boston University, USA
Russell Faux, Davis Square Research Associates, LLC, USA
Anna Victoria Garik, Boston University, USA

ABSTRACT
In return for a tuition scholarship, Noyce Scholars make a commitment to teach in a high-need school district for two years after completing their licensure program. If this commitment is not satisfied, the scholarship must be repaid. We have surveyed 42 graduates of our program from the past 8 years to study the importance of the scholarship relative to the Scholars' social commitments and retention, and learn whether their teaching practices are those associated with culturally competent teaching (CCT). The survey further inquired how effective the Scholars found different CCT practices. We find on the whole that the Scholars are practicing CCT, and that their commitment to social justice outweighs the importance of the financial obligation of the scholarship.

Promoting culturally responsive STEM education in Indigenous serving schools through in-service teacher professional development.

Pradeep Dass*, Northern Arizona University, USA
Angelina Castagno, Northern Arizona University, USA
Darold Joseph, Northern Arizona University, USA
Chesleigh Keene, Northern Arizona University, USA

Crystal Macias, Northern Arizona University, USA

ABSTRACT
This project was designed to engage teachers of Indigenous students in a rich, content-focused, long-term professional development program, honoring their cultural expertise to design culturally responsive STEM learning experiences. Teachers work with content expert university faculty over eight months to gain content mastery, develop grade/subject specific STEM instructional units, and learn to become effective pedagogues. Program impact on teachers' ability in STEM curriculum development (high quality instructional units), instructional practice, and incorporation of culturally responsive approaches to STEM education was investigated using the SCOOP Notebook protocol; an internally developed and validated questionnaire to assess elements of culturally responsive practices specific to the Indigenous context; and focus group interviews of faculty facilitators and teacher leaders in the program. Results indicate positive impact of the program on each area investigated (curriculum development, instructional practice, and culturally responsive pedagogy), indicating the effectiveness of the professional development program and the content-rich learning model it employs, which is based on the Yale National Institute© (YNI) model of K-12 in-service teacher professional development. Implications of promoting culturally responsive STEM Education, specifically in Indigenous contexts, to improve student interest and accomplishment in STEM will be discussed.

School-University partnerships in support of equitable primary science education

Maiza Trigo, The University of Luxembourg, Luxembourg
Ragnhild Barbu, The University of Luxembourg, Luxembourg
Sara Wilmes, The University of Luxembourg, Luxembourg
Kerstin te Heesen, The University of Luxembourg, Luxembourg
Christina Siry*, The University of Luxembourg, Luxembourg

ABSTRACT
This presentation explores a school-university partnership that supports in-service primary teachers to engage in science education in ways that are responsive to diverse students' and teachers' needs. We present an overarching case study of a team of five researchers and seven collaborating teachers, working together in a school-university partnership to explore how different initiatives have emerged from - and responded to - primary science professional development needs. An interpretive analytic lens reveals a multilayered process of building of communities of practice, the possibilities of shifting toward open-ended teaching approaches and reflections on tensions within a rapidly changing context. Participatory research (considering field notes, reflection papers and focus groups) reveals the team's dynamics towards an endeavor to support transformative science education. The (blinded) Project uses a structure of collaboration built upon reflect / dialogue /-act, which enables an analytical framework on power and agency, while spotlighting: i. the need for building sustainable partnerships; ii. The contradictions faced in building school-university partnerships, based on trust and awareness; and iii. the reflection on one's own identity and professional change. Grounded in participatory processes, views of long-term sustainable school-university

partnerships illuminate the need for ongoing dialogue and the critical need for building trusting relationships.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Developing and Assessing Science Teacher Learning
4/18/23, 16:45-18:15, Salon A4 (LL)

Towards a Typology of Science Teachers Engagement in Learning

Irit Vivante*, Ben Gurion University in the Negev, Israel
Dana Vedder-Weiss*, Ben Gurion University in the Negev, Israel

ABSTRACT
Engagement is critical for learning processes and outcomes. Teachers' engagement in learning affects their professional development and, hence, their teaching. However, only scarce research explores teacher engagement in professional learning. On this background, this mixed method study aims to typologize teachers in professional development sessions according to their engagement profile. Our research combines quantitative analysis of video-recorded data with qualitative analysis of observations and field notes. We examined both verbal and embodied engagement of thirty elementary and middle school science teachers in PD sessions (a total of 21.5 hours). We identified four types of teacher engagement: Enthusiastic (commonly highly engaged across verbal and embodied modes); (2) Blunt (commonly disengaged across all modes); (3) Concealed (often engaged and exhibits more embodied engagement than verbal engagement); and (4) Deluding (often disengaged and exhibits more embodied disengagement than verbal disengagement). The findings show the significance of examining teacher engagement not only as verbally exhibited but also as manifested through their bodies. This study advances our understanding of teachers' engagement during PD. In practice, awareness to the four teacher engagement types can hone PD facilitators' assessment of their instruction, as well as teachers' perceptions of themselves as learners.

Developing biology teachers' pedagogical content knowledge in evolution: a case study with two experienced teachers

Arlette Bassaber*, Universidad Católica de Valparaiso, Chile
Claudia Vergara, Alberto Hurtado University, Chile
Hernan Cofre, Universidad Católica de Valparaiso, Chile

ABSTRACT
This study presents how two in-service biology teachers develop her PCK for evolution. For capturing PCK a CoRe interview to both teachers before and after they teach the unit evolution was applied. The unit were videorecording and analyses with a PCK procedural rubric adapted. Specific situations of each teacher, were selected and a Pap-Ers was applied. The interview was analyses with a qualitative content analysis using the components of PCK. Among the results, it can be pointed out that there is coherence between the components of declarative and procedural PCK. Both teachers show differences in the number of elements they express

associated with each of the components, as well as different levels of depth of knowledge they have regarding each of these components, although they also present common elements. It can be concluded that the lower the initial PCK of a teacher, the more accentuated the development of the same presents a progressive increase, whereas if the teacher starts with a higher PCK, its progression becomes more difficult throughout the unit. By reflecting on the practice and have accompaniment, certain aspects could be mobilized , which does not impact in the same way in the development of their PCK in evolution

Exploring power amidst curricular reform through the language of teachers' episodes of pedagogical reasoning

Kevin Fleming*, The George Washington University, USA
Jonathon Grooms*, The George Washington University, USA
Alan Berkowitz, Cary Institute of Ecosystem Studies, USA

ABSTRACT
A critical discourse analysis of teachers' episodes of pedagogical reasoning was conducted exploring teachers' sense of power as agentic or oppressive while enacting curricular reform. Findings show an oscillation between both where teachers are empowered to actively contribute to reform efforts and engage in professional learning but also oppressed in their ability to reach reform goals.

Application of implementation criteria to evaluate the outcomes of science teacher action research

Dace Namsone*, University of Latvia, Latvia
Kārlis Greitāns, University of Latvia, Latvia

ABSTRACT
Science teacher professional development (STPD) intervention design has emerged as one of the most dominant research topics in science education research. Previous research has identified more and more design elements, that characterize effective STPD, still not all STPD interventions that include the identified elements reach the ultimate goal – changes in teachers' practice and student results. In the last decade, action research has been recognized as an emerging strategy to reach changes in science teacher practice, still, not all teachers who engage in action research reach equal results. This research is an attempt to gain insights, into how changes in teacher practice are reached through action research, using implementation science research methods, an emerging methodology in STPD research. In this research, the authors apply the lens of the eight implementation outcomes to study the case of science action research at the individual participant level. The levels of changes in science teacher practice are evaluated and explained through the evaluation of the eight implementation outcomes. The results suggest that changes in teacher practice and student results are reached when the action research is qualifiedly implemented by participants; teachers' feasibility to conduct action research determines whether changes in student results are achieved.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set: Evidence-based designing for science instruction
4/18/23, 16:45-18:15, Astoria (L3)

Fields in middle school energy instruction to support continued learning of energy

Kristin Fiedler*, Leibniz Institute for Science and Mathematics Education, Germany
Marcus Kubsch, Leibniz Institute for Science and Mathematics Education, Germany
Knut Neumann, Leibniz Institute for Science and Mathematics Education, Germany
Jeffrey Nordine, Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
Science education research has repeatedly shown students problems in understanding energy, in particular their understanding of potential energy. Newer research suggests that teaching students fields as a means to store potential energy may promote a more consistent understanding of the energy concept. Yet, it is presently unknown if the helpfulness of fields is limited to particular manifestations of potential energy or if the conceptualization of potential energy as energy stored in fields may constitute a coherent approach that supports students' continued learning on energy. To address this issue, we carried out a quasi-experimental pre-post-test study (written assessments with a mixture of multiple-choice and open-ended items, N=64 in grade 6). We compared students continued learning in the context of electric energy in a subsequent energy unit in which students were assigned to either the experimental (fields-based approach) or control (non-fields-based approach) condition according to their assignment in an introductory unit. Our findings indicate that students in the fields-approach outperformed students in the non-fields-approach. They seemed to be able to use their prior understanding on potential energy to make sense of the previously unknown form of electric energy. The results of our study imply that fields do support continued learning about energy.

Tracking the Collaborative Design of a Culturally Relevant Environmental Chemistry Unit

Jeffrey Spencer*, University of Michigan, USA
Danielle Maxwell, University of Michigan, USA
Kaare Sikuaq Erickson, Ikaagun Engagement, USA
Linda Nicholas-Figueroa, I_isa_vik College, USA
Kerri Pratt, University of Michigan, USA
Ginger Shultz, University of Michigan, USA

ABSTRACT
Science education often portrays content from the perspective of traditional Western academic perspectives. As a result, non-majority students often struggle to relate classroom material to their lived experiences and culture. Although cultural relevance gains momentum, salient examples remain sparse in postsecondary chemistry. This collaborative design project explores how culture and context influence the design and implementation of culturally relevant curricular materials for introductory chemistry at a Tribal College in Northern Alaska. Participating students learn about Arctic snow processes by working with community members, Elders, and scientists to design and implement a research project that integrates

local, traditional, and scientific perspectives. We outline the design considerations used to construct and implement a culturally relevant chemistry unit and describe activities where students interacted with the community and selected resources to inform their research design. Throughout four iterations of the unit, we use conjecture mapping to track the design considerations, organize data collected throughout our partnership, and present reflections that inspired adaptations made to make the unit more culturally relevant for the context of the course.

A rose by any other name … COVID-19 and arguments about the use of "Chinavirus"

David Owens*, Georgia Southern University, USA
Michael Reiss, University College London, United Kingdom

ABSTRACT

We examine the acceptability or not of referring to the virus that causes COVID-19 as "the Chinavirus." We explore the potential for inducing perspective taking in the development of arguments regarding the appropriateness of this term. The large majority of 43 US undergraduates who participated were able, having undertaken an on-line coronavirus-themed unit, to provide arguments both for and against referring to the virus as "the Chinavirus" and to use different perspectives in articulating their own position on the issue. Arguments in favor of the appropriateness of the term "Chinavirus" tended to maintain that China was the origin of the virus, and argued that China was, in one way or another, responsible for the origin of the virus. Arguments in favor of the inappropriateness of the term "Chinavirus" mostly maintained that this was discriminatory, even racist, and could be harmful to those of Asian descent. The overwhelming majority of students concluded that it is inappropriate to call the coronavirus "Chinavirus." We conclude that induced perspective taking has the potential for exposing the evidence and reasoning employed by opposing sides of SSI from which progressive dialogue can commence.

Teachers' Descriptions and Rationales of Customizations of Storyline Science Curriculum: Adapting for Their Classroom Contexts

Katherine McNeill*, Boston College, USA
Caitlin Fine, Metropolitan State University of Denver, USA
Benjamin Lowell, Boston College, USA
Renee Affolter, Boston College, USA

ABSTRACT

Curriculum can serve as an important tool to help teachers shift their classroom instruction. However, high quality enactment of curriculum does not look identical in every classroom, because teachers need to be responsive to their students. We investigated what types of customizations teachers made while enacting storyline science curriculum and their rationales for those changes. Specifically, we collected two data sources: a teacher survey and follow-up interviews. The survey was completed by 169 participants with 20 follow-up interviews. The analysis suggests that teachers were more likely to make in-the-moment changes in response to students' needs (e.g. re-arranging seating during a discussion) rather than students' ideas (e.g. whether a magnetic field can have a negative force). When providing specific examples of changes, the four most common goals were: engagement & participation, more support for students, time and logistics. Teachers' customizations tended to align more closely with the vision of the storyline curriculum for some goals (e.g. engagement & participation) and less for other goals (e.g. increase support for students). Future work should research professional learning to support teachers in considering students' ideas and the goals behind their changes, particularly to keep an asset oriented view that centers students in the work.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set: Centering the Experiences, Pedagogies, and Needs of Black Women Science Teachers
4/18/23, 16:45-18:15, Salon A1 (LL)

But That's Just Good Science Teaching!: An Argument for Historically Relevant Science Pedagogy

Alexis Riley*, Cal State LA, USA

ABSTRACT
Marginalized communities cannot and do not have decontextualized experiences with how socio-scientific issues, such as exposure to COVID-19 as frontline essential workers, high Black infant mortality rates, air pollution leading to respiratory problems, and other issues, affect their community. As K-12 science teachers and teacher educators strive to dismantle oppressive practices in their classrooms and curriculum, it would be helpful to learn from Black women science teachers who have been engaging in anti-racist practices before the racial awakenings of Summer 2020. In this study, three different virtual focus groups, or Sista Circles, were conducted with 18 Black women secondary science teachers. These Sista Circles had a wide range of experience, ranging from 1 to 22 years of experience, with teachers across the country, including international participants. Black women science teachers enact antiracist science teaching by bringing something new to the community; using NGSS standards within the context of the community; teaching at the intersection of history, culture, and science learning and teaching; and building critical consciousness in the science classroom. When considering how science teaching and learning can be used within culture-based frameworks, I offer ‘historically relevant science pedagogy' as an anti-racist framework for the science classroom.

Racialized Gendered Experiences Black Women Science Teachers Endure Both With and Outside of the Classroom

Olayinka Mohorn-Mintah*, The University of Memphis, USA

ABSTRACT
It has been shown that Black women are typically viewed through a narrow lens of salient, racialized and gendered stereotypes, and as a result struggle to be seen as capable professionals and contributing members of society (Collins, 2000; Harris-Perry, 2013; Jones & Shorter-Gooden, 2003). Informed by a sociocultural framework of identity construction coupled with a Black feminist lens, I employed a narrative inquiry approach to learn from the

experiences of five Black female veteran teachers while teaching in urban secondary science classrooms. The teachers in this study shared that were victims of microaggressions because of their positionality as a Black female teacher of science. Implications of study findings include the need for school districts to improve job conditions for Black female science teachers by educating administrators about Black women's experiences with microaggressions. This will aid them in properly interpreting classroom practices they observe and more deeply understanding how urban school environments can serve as hostile spaces for Black female science teachers. These understandings can be used to create school structures that are tailored to combat issues unique to Black female science teachers.

The Need for Black Women Only Spaces in Science
Jordan Henley*, University of Georgia, USA
Mary Atwater, University of Georgia, USA

ABSTRACT
There is a disproportionately low number of Black women teaching high school science (Banilower et al., 2018; U.S. Department of Education & National Center for Education Statistics, 2020). There are many factors that contribute to this low number beginning with the historic exclusion of Black women from science and how Black girls experience science in school. In teacher education programs and as in-service teachers Black women experience racism, sexism, and have their experiences devalued (Beard, 2020; Brown, 2014; Carver-Thomas, 2017; Cheruvu et al., 2015; Mensah, 2019; Milner, 2008; Mohorn, 2021; Souto-Manning & Emdin, 2020). Once they begin teaching, Black women are exposed to racism and sexism from parents, students, and colleagues.
To learn more about how to combat these issues, this study centered on the question of what are the experiences and needs of Black women secondary science teachers throughout their careers? This study was completed as a case study and data were collected through interview and journal entries from fur Black women teaching high school science. Findings support the creation of spaces for Black women within science education to provide a space for growth, inspiration, and community in a field where Black women are often isolated.

Developing Racial Literacy with a Black Woman Science Teacher: A Counterstory
Felicia Mensah*, Columbia University, USA
Alexis Riley, Cal State University - Los Angeles, USA
Jordan Henley, University of Georgia, USA
Olayinka Mintah, University of Detroit, USA
Althea Hoard, Relay Graduate School of Education, USA

ABSTRACT
This study utilizes intersectionality to center the counterstory of an African American woman science teacher who engages in a Black Feminist book club to deepen her racial literacy. The findings show the ways racism, propagated by many experiences—including images of scientists, relationships with teachers, and expectations of peers and family—influenced her educational pathways in the sciences and her experiences teaching science. Even more, as the teacher explored her science identity, she recognized discriminatory structures of power that

disadvantage her Black female science students. African American women science teachers who have pathways to unpack the role of racism in their science life histories are better equipped to integrate culturally relevant teaching practices and to be sustained in the teaching profession. This study suggests the usefulness of intersectionality as a theoretical framework to co-construct racial literacy development with African American (and all) science teachers.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set: Exploring the urgency of climate change literacy
4/18/23, 16:45-18:15, Blvd C (L2)

"I am very disappointed in humankind." – Students' Perspectives and Emotions on Current Climate Change Education

Andrea Moeller*, University of Vienna, Austria
Johanna Kranz, Center of Excellence for Climate Change Impacts, Germany
Veronika Winter, University of Vienna, Austria

ABSTRACT
Schools and their students can play an essential multiplier role in the societal transformation towards climate neutrality. In this context, so far, science education research seems to focus on the investigation of students' individual parameters such as content knowledge or pro-climate behavior and a discussion oriented towards deficiencies in this respect. Conversely, little is known about how students themselves evaluate their previous climate change education (CCE) and the role of schools in climate protection. For this purpose, we conducted a qualitative questionnaire study using the example of 80 secondary school students (grade 12) in Austria. Our results indicate that students feel inadequately prepared for their role as possible climate action multipliers by their schools, stating that the topic of climate change is given too little time and the practical examination of solutions is missing. Results indicate that educators need to especially take into account students' affective disposition towards the topic, such as the perceived lack of self-efficacy. To best prepare students for their engagement in the climate-neutral transition, science education research and educators need to increasingly take into account the needs of students and systemic hindrances in the education system in order to overcome the identified challenges towards effective CCE.

Teachers' rationales and approaches for teaching for climate change actions in secondary science classrooms

Lisa Borgerding*, Kent State University, USA
Breanna Beaver, Kent State University, USA
Adepeju Prince, Kent State University, USA
Jennifer Heisler, Kent State University, USA

ABSTRACT
Climate change is an urgent global problem caused by human action, and human action is essential for mitigating further greenhouse gas emissions and adapting to climate change's

global impacts. Climate change education for climate action is needed to develop an informed citizenry willing and capable of carrying out mitigation and adaptation efforts. The purpose of this mixed methods study is to examine secondary science teachers' rationales and approaches for addressing climate change action in their classrooms. The sample consisted of 86 Midwestern secondary science teachers who were surveyed about their teaching practices related to climate actions. Twenty-six of these surveyed teachers were individually interviewed to elaborate on their responses. The findings from this study illustrate how climate change instruction often centers upon student engagement and content delivery without addressing or offering opportunities for climate change action. The qualitative accounts of teachers' approaches for teaching for action are suggestive of specific action-oriented curricula that can be developed, needed professional learning to support action-based instruction, and needed teacher education that invites future teachers to adopt more action-oriented climate change teaching roles.

Strand 15: Policy, Reform, and Program Evaluation
Related Paper Set: Leadership for the Promotion of Equity in Science and STEM Education
4/18/23, 16:45-18:15, Salon C7-8 (LL)

District Science Coordinators' Conceptions of and Levers for Advancing Equity Agendas

Christa Haverly*, Northwestern University, USA
Elizabeth Davis*, University of Michigan, USA
Angela Lyle, University of Michigan, USA
Emily Seeber, University of Michigan, USA

ABSTRACT
Using equity frameworks from NASEM (2022), Philip & Azevedo (2017), The Leadership Academy (2021), and Khalifa and colleagues (2016), this paper seeks to better understand how district science coordinators (DSCs) understand equity as it relates to their efforts to improve elementary science instruction and the levers that they use to effect change to these ends. Data is drawn from semi-structured interviews with predominantly White district science coordinators located across the United States in 13 urban, suburban, rural, and charter school systems. Results show that DSCs overwhelmingly rely on conceptions of access, opportunities, and representation to frame their equity work with elementary science, with a few outlier examples of more critical understandings of racial justice. For most DSCs, their primary lever of influence is through the establishment of high-quality curriculum materials given the challenges they face in offering professional learning opportunities to elementary teachers across even the smallest districts. The paper highlights a few exceptions where equity and justice are central to instructional vision statements, or the DSC intentionally diverts resources to schools most in need rather than maintaining equal access across the district.

How Elementary Principals Support Equity-Focused STEM Teaching and Learning

Tia Madkins*, The University of Texas at Austin, USA
Joshua Childs*, The University of Texas at Austin, USA

Ain Grooms*, University of Wisconsin, Madison, USA
Stefanie Marshall, University of Minnesota, USA

ABSTRACT
For several years, stakeholders have worked to expand STEM education learning opportunities for minoritized students based on local and national policies to promote equitable access. School leaders play an important role in how these policies are taken up in local contexts, yet we know little about how these leaders understand STEM content. Thus, a better understanding of how school leaders, especially those at schools serving high numbers of minoritized students, can leverage these equity-focused practices is key to increasing minoritized students' participation and success in STEM. This study seeks to provide insights about and guidance for school principals' professional needs to engage as instructional leaders related to equity-focused STEM education efforts. The present study draws upon data from a larger, comparative case study to understand how school leaders understand and support their school communities in implementing equity-focused STEM + computer science initiatives. Based on analyses of interviews and artifacts collected from eight elementary school principals working in urban, suburban, and rural settings, several themes emerged. Study findings illuminate how school leaders navigate STEM education initiatives in their respective elementary schools. This study highlights the importance of school leaders in implementing and sustaining STEM initiatives, courses, and policies within schools.

Developing Elementary STEM Teacher Leaders

Amanda Gunning*, Mercy College, USA
Kristen Napolitano, Mercy College Center for STEM Education, USA
Elena Nitecki, Mercy College, USA
Meghan Marrero, Mercy College, USA

ABSTRACT
In this qualitative case study, six elementary teachers comprise the case studied during three years of participation in a fellowship designed to increase STEM teacher leadership. Teachers participated in two graduate-level courses on STEM pedagogy and monthly professional development opportunities and/or meetings. Findings illustrate how the teachers developed an increased self-efficacy for teaching integrated STEM units and lessons during this time and developed leadership identities. All participants took on greater leadership roles in their schools/or districts. By using Bandura's four modes of self-efficacy development (1997) as a lens, we share how teachers were supported on their journeys.

District Science Coordinators' Promotion of Equity in an Organization

Shaugnessy McCann*, University of Georgia, USA
Yamil Ruiz, Clemson University, USA
Brooke Whitworth, Clemson University, USA
Julie Luft, University of Georgia, USA
Joon Kum, University of Georgia, USA

ABSTRACT
District Science Coordinators (DSCs) play an important role in supporting science teachers to create equitable learning environments for all students. Taking an organizational learning theory approach (Schön, & Argyris, 1996), we explore how DSCs describe their role in promoting equity within their district. Two cohorts of DSCs (n = 22) participated in a professional development program designed to support their leadership and knowledge of NGSS-aligned instruction with an explicit focus on equity. Data include surveys, interviews, focus group interviews, and strategic plans. Results suggest that DSCs may have the potential to effectively promote equity within the district. However, that potential may be constrained by both administrative factors and the need for high-quality, strong relationships with teachers in order to effect change. Substantive, consistent administrative support and shared vision emerge as important factors needed to impact the organization in meaningful ways when it comes to promoting equity.

Presidential Reception

4/18/23, 19:00-20:30, Grand Ballroom (L2)

Conference attendees, please join us for a reception in the Grand Ballroom!

Social Event
Mind and Sole Fun Run
4/19/2023 6:00-8:00

Meet in the conference hotel lobby!

Research Interest Group Business Meetings
4/19/2023 7:00-8:15

Salon A1 (LL)
Asian and Pacific Islander Science Education Research (APISER) RIG Meeting

Salon A2 (LL)
Latino/a RIG (LARIG) Meeting

Salon A3 (LL)
Contemporary Methods for Science Education Research RIG Meeting

Salon A4 (LL)
Engineering Education RIG (ENE-RIG) Meeting

Salon A5 (LL)
Indigenous Science Knowledge RIG (ISK-RIG) Meeting

Salon C1-2 (LL)
Research in Artificial Intelligence-Involved Science Education (RAISE) RIG Meeting

Salon C3-4 (LL)
Continental and Diasporic Africa in Science Education RIG (CADASE) Meeting

Concurrent Session 3
4/19/23, 8:25-9:55

Roundtables Session 1
4/19/23, 8:25-9:55, Salon A5 (LL)

Topic 1: Middle School Science

Strand 15: Policy, Reform, and Program Evaluation
Shifting Expectations for Authentic Inquiry in Namibian Junior Secondary Life Science Designated Curriculum
Rachel van Aswegen*, University of Virginia, USA
Lillian Bentley, University of Virginia, USA

ABSTRACT
Designated curricula are the initial source of information on what, when, and how teachers should enact their instruction, and hold expectations from governing bodies for learning experiences teachers should incorporate into their teaching. In Namibia, these curricula come in the form of subject syllabi, curriculum documents, and national exams. As the country and international education experts express a commitment to authentic inquiry, especially in Life Sciences, it is vital to evaluate how this commitment is supported by national documents guiding instructional choices. When designated curriculum components are aligned with each other around specific practices, like authentic inquiry, teachers are better able to integrate these practices into their instructional decisions. This study will analytically examine the expectations embedded in Namibian Junior Secondary Life Science designated curricula and outline implications for policy and practice.

Strand 12: Technology for Teaching, Learning, and Research
Enhancing middle school physical science lessons with embodied learning
Jonathan Margolin*, American Institutes for Research, USA
Connie Chandra, American Institutes for Research, USA
Lawrence Friedman, American Institutes for Research, USA
Katherine Guyot, American Institutes for Research, USA
Michaela Labriole, New York Hall of Science, USA
Megan Legault, American Institutes for Research, USA
Amelia Roach, American Institutes for Research, USA
Laycca Umer, New York Hall of Science, USA
Stephen Uzzo, National Museum of Mathematics, USA

ABSTRACT
In this paper we summarize exploratory research in the use of embodied learning in middle school physics instruction using the Playground Physics Program, an intervention consisting of a technological platform (Playground Physics App), along with a program of professional

development, curriculum, and an electronic community of practice. The Playground Physics program is based on evidence suggesting that the embodiment of physics concepts using a playful, inquiry-based approach provides opportunities for students to deepen engagement with, and understanding of physics concepts The study provides evidence that the classroom implementation of Playground Physics afforded students opportunities to engage in directly embodied activities, that these activities support physics instruction and enhance student engagement, and that they believe the curriculum supports physics instruction and helps students visualize physics concepts.

Strand 1: Science Learning: Development of student understanding

Comparing Levels of Integration of Visual Representations within US Middle School Life Science Textbooks

Mary Nyaema*, University of Illinois, Chicago, USA
Nurcan Keles, Dicle University, Turkey

ABSTRACT

The goal of the study was to compare how visual representations were integrated into the contents of three US middle school Life Science textbooks. Purposeful sampling was used to select the 6th, 7th, and 8th topics present in all three textbooks. The coding scheme was designed using categories adapted from a rubric used in Gkitzia et al. (2011). The functional category from Pozzer and Roth's (2003) study was included as an additional category. The visual representations were coded into five categories representative of the level of integration. The findings of the study revealed that although all textbooks are centered around the NGSS curriculum, there are differences in the way in which visual representations are integrated with the text. This presentation urges teachers, educational researchers, curriculum developers, and future textbook authors to rethink the use of visuals and their integration into textbook content. It also indicates a further need to clarify appropriate ways to measure and evaluate the integration of visuals and text in middle school Life Science within the NGSS curriculum.

Topic 2: Affective issues in teaching and learning

Strand 2: Science Learning: Contexts, Characteristics and Interactions

A qualitative analysis of impostor phenomenon among discipline-based education researchers

Devasmita Chakraverty*, Indian Institute of Management Ahmedabad, India

ABSTRACT

Impostor phenomenon occurs when successful individuals cannot internalize their success, attributing it to luck, connections, or other's kindness. It has been studied in several contexts in science, technology, engineering, and mathematics (STEM), but not in discipline-based education research (DBER), that includes the scholarship of teaching and learning of the domain subject in classrooms. This research uses a framework of "othering" to address the research question: "How do discipline-based education researchers experience impostor phenomenon especially during their transition from STEM to DBER?" US-based DBER-persons were invited to participate through various email listservs using convenience/snowball sampling. Semi-structured interviews were conducted with 21 self-selected participants who reported impostor experiences. Interview transcripts were coded and analysed inductively using constant comparison. Four themes were constructed: challenges of transitioning from STEM to DBER; legitimacy of educational research methodologies; lack of adequate mentoring; and the divide between STEM and DBER. Findings indicate various axes of othering that made it difficult to develop belongingness while transitioning from STEM to DBER. The hierarchical nature of STEM made participants feel their research was less impactful and methodologically sound. Deeper exploration of impostor phenomenon in DBER would help develop strategies to reduce alienation, improve belongingness, and strengthen the workforce.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Misery Creates Company: Female Student-Developed Support Systems in Physics Classes

Mihwa Park*, Texas Tech University, USA

ABSTRACT

Learning science is often viewed as a cognitive process while emotions are temporal reactions to events as bi-products, and negative emotions as an impediment to learning and thinking rationally. This indicates that emotions' influences on learning and doing science have not been fully investigated. Therefore, this project aims to find evidence for the effect of students' emotions on their learning science to provide solid evidence for the importance of students' emotions to education. The study was conducted in an inquiry-based physics class in a large university in the U.S. In the class, students worked together in groups to complete each task as they devised experimental procedures. A female student participated in the study. Data included student emotion diaries, researcher field notes and interviews with the student. Analysis results show that sharing negative emotions between group members and being compassionate with each other, the participant student was able to actively engage in group activities. Also, a teacher's help with showing empathy about students' struggles in learning helped students build confidence in learning and doing physics. The results from the first week of interview with Alex and her diary showed that students' emotions influence their epistemic pursuits and their social engagements.

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

Attention to Student Emotions and Teacher Vulnerability as Tools to Maintain Student Disciplinary Engagement

Jennifer Schellinger*, Florida State University, USA
Lama Jaber*, Florida State University, USA
Sherry Southerland*, Florida State University, USA

ABSTRACT

Research on students' engagement suggests that epistemic affect--that is, the feelings and emotions experienced in the epistemic work of making sense of phenomena-- should be recognized as a central component of meaningful disciplinary engagement in science. These feelings and emotions are not tangential by-products, but are essential components of disciplinary engagement. Yet, there is still much to understand about how educators can attend and respond to students' emotions in ways that support disciplinary engagement in science. To inform these efforts, we follow one high school Biology teacher, Amelia, to answer the following question: How does Amelia attend to and support her students' emotions in ways that support their disciplinary engagement? Data examined include teacher interviews and classroom recordings of two multi-day science lessons. We found that the teacher worked to support her students' emotions in moments of uncertainty in at least two ways: (1) by attending to these emotions directly, and (2) by sharing her personal experiences and feelings in engaging in similar activities as a science learner. We describe how Amelia made herself vulnerable to students, describing her own struggles in making sense of phenomena, in turn supporting her students to normalize these experiences as part of doing science.

Strand 10: Curriculum and Assessment

Embedding Formative Assessment in Inquiry-Based Teaching: Students' Conceptual Learning

Feral Ogan-Bekiroglu*, Marmara University, Turkey
Simay Koksalan, Middle East Technical University, Turkey

ABSTRACT

This research aimed to examine the effects of embedded formative assessment in inquiry-based learning on students' conceptual understanding. Mixed method experimental research design with quantitative and qualitative data collection methods was carried out for this research. The participants of the study were 41 tenth grade students. The following conclusions are drawn from the results. First, formative assessment combined with inquiry-based teaching serves as a catalyst for students' conceptual learning and elevated effects of inquiry. Second, eliciting evidence of learning and feedback are the most important steps of formative assessment in accelerating student learning and supporting student knowledge development. This study suggests that assessment should be done when teaching continuous and teachers need to adopt formative assessment during inquiry-based teaching.

Topic 3: Issues in College STEM Teaching

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

Pedagogical Partnership: Collaborative Design of a Program to Support Pedagogical Improvement for University Engineering Instructors.

Kerry Rose*, University of Alberta, Canada
Mijung Kim*, University of Alberta, Canada
Janelle McFeetors*, University of Alberta, Canada
Qingna Jin*, University of Alberta, Canada

ABSTRACT

Student-centered and active learning pedagogies are known to improve learning outcomes for undergraduate engineering students, especially for typically underrepresented groups. However, lecture-based (instructor-centered) teaching still predominates as the primary (and often only) mode of instruction in Canadian undergraduate engineering classrooms. As a means to promote pedagogical change, a partnership was formed between a Faculty of Education and a Faculty of Engineering at a large Canadian university in order to create a

program that aims to shift pedagogical practice of undergraduate engineering instructors (professors) toward more student-centered, active learning pedagogy. The development and interaction of this cross-disciplinary partnership between knowledgeable collaborators (program developers, researchers, students and users) is described using a Situated Learning conceptual framework. As signature pedagogical perspectives (engineering and K-12 education) intersected, attention to the differing cultures of instruction, with purposeful consultation between stakeholders, allowed for all involved groups to experience how expertise from differing perspectives, in a socially and culturally moderated learning environment, can lead to understandings that allowed for the the eventual creation of a 12 module, 2 year program that uses evidence-based and contextually sensitive learning activities to help engineering instructors to improve their pedagogical practice.

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

Scientific Caricatures in Online Science Classrooms: Alternative Assessment Effectiveness in Virtual Environments

Renee Clary*, Mississippi State University, USA

ABSTRACT

Students (N=54) enrolled in a university graduate level online Earth History course were offered an optional examination assignment in 2019, 2020, and 2021. Scientific caricatures (SCs), a unique, historical visualization tool that encapsulates scientific debates, were used by 19th century scientists to challenge or ridicule proposed theories. SCs were integrated throughout the Earth History course, and students had the option to construct their own SC, on a selected number of topics, as part of each course examination. T-statistics (_ = 0.05) revealed that students who participated in SC options scored significantly higher on most examinations in 2019 and both examinations in 2020, with medium-to-large effect sizes. While not significant, other examinations (2019, 2021) still documented higher averages for SC-participating students. Content analysis of student survey responses revealed three stable findings: 1) students perceived that creativity was of principal importance for SC construction; 2) SCs engaged students in learning content, even if they did not construct one; and 3) Students acknowledged that SC construction required additional research and deeper understanding of science. SCs can expand the assessment repertoire in online courses to measure meaningful learning, although additional research is needed to determine SC effects and benefits in virtual environments.

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

Teaching Biology: A review about the contribution of Research

Claudia Vergara*, Alberto Hurtado University, Chile
Beatriz Becerra, Universidad Catolica de Valparaiso, Chile
Paola Nuñez, Universidad Catolica de Valparaiso, Chile
David Santibanez, Finnis Terrea University, Chile
Hernan Cofre*, Universidad Catolica de Valparaiso, Chile

ABSTRACT
This paper presents findings from a content analysis of 711 empirical biology education research papers published in two top-tiered biology education journals (Journal of Biological Education and CBE Life Science Education), and five top-tiered science education journals (International Journal of Science Education, Journal of Research in Science Teaching, Research in Science Education, Science Education and Journal of Science Education and technology) from 2010–2021. We found that the most highly published area of research were ecology, evolution, and human biology. Most of the studies were conducted in higher education and high school context and in the United States. Considering the results, topics that need further study are recognized, such as learning and teaching at the pre-school level and in specific topics of cell biology and human biology such as the nervous system or developmental biology.

Topic 4: Clarifying the Nature of Science

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

Definition vs. Objective: A Century Old Struggle of Nature of Science Framework

Caglin Akillioglu *, Middle East Technical University, Turkey
Semra Sungur, Middle East Technical University, Turkey
Jale Cakiroglu, Middle East Technical University, Turkey

ABSTRACT
The adequate conception of nature of science has been presented as the agreed-upon objective of science education by most researchers and educators for a century. However, from the early attempts to define the nature of scientific knowledge, nature of scientific theories, and nature of scientific enterprise, defining nature of science remained a challenge. Researchers studying nature of science generally respond to the lack of definition in two ways. Some researchers claim that these agreed-upon aspects can be studied without a definition because there is sufficient agreement on the aspects of nature of science in the literature. Others promote alternatives to this notion by assuming that it is implausible to reach an agreed-upon definition of nature of science due to its ambiguous philosophical underpinnings. Despite these discussions, referring to the adequate conception of nature of science as an objective instead of providing a definition is an established practice even among the critiques. Therefore, this observed tendency begs the question, `How could this framework become the most influential and powerful voice in the science education literature without having an agreed-upon definition of the very concept it was built upon? Are there other frameworks in education literature or other fields' resembling this phenomenon?

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

An image of science practices from an ethnography of professional coffee roasters

Bradley Davey*, Northwestern University, USA
Reed Stevens, Northwestern University, USA

ABSTRACT
Images of science influence what we count as science, how we believe it is conducted, and what and how we teach. This paper advances an image of science conducted not within professional laboratories, but rather an everyday workplace: a neighborhood coffee roastery. Through participant observation and microethnographic analyses we develop and analyze a vignette of coffee roasters in action and situate their work within the "practice turn" of science education. This vignette portrays an embodied way of knowing that coffee roasters use as part of their broader repertoire of practices. We show that these practices bear family resemblance to those elevated by the Science and Engineering Practices of the Next Generation Science Standards and discuss their implications for science teaching and learning.

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

Representation of social-institutional aspects of science in the science textbooks: Textbook analysis and teachers' views

Beyza Okan*, Bogazici University, Turkey
Ebru Kaya, Bogazici University, Turkey

ABSTRACT
This study includes both textbook analysis and teachers' views on the inclusion of social aspects of science in the science textbooks. The paper was grounded on the Reconceptualized Family Resemblance Approach to Nature of Science [RFN] which defines science as an epistemic, cognitive, and social institutional system. The social categories are social certification and dissemination, professional activities, scientific ethos, social values, social organizations and interactions, financial systems, and political power structures. Four science textbooks and eight science teachers using those science textbooks were selected for this study. Textbook analysis showed that the explicit references to social-institutional aspects of science are very limited. Although there are some emphases on some categories, no clear statements aiming to teach these categories have been found. Besides, most of the teachers stated that they do not use the textbooks in teaching NOS because of the insufficient emphasis on the NOS in the textbooks. The textbook analysis and teachers' views support each other. They stated that most of the categories are missing in the textbooks or underrepresented. As a suggestion the science textbooks should offer a holistic representation of social systems of science for students to understand the nature of science in a deep sense.

Topic 5: Science Teacher Preparation

Strand 7: Pre-service Science Teacher Education

Feeling Like a First Year Teacher All Over Again: Teaching Elementary Science Methods During Covid-19

Valarie Akerson*, Indiana University, USA
Ingrid Carter, Metropolitan State University of Denver, USA
Claire Cesljarev, Indiana University, USA

ABSTRACT
A university professor teaching elementary science methods conducted a self-study on her teaching during Covid 19 in a hybrid online/in person class to determine best practices in the situation in which she found herself. Data collection included maintaining a researcher/teacher log, meeting with a critical friends group (recorded and transcribed) where questions were raised and suggestions were made for improvement. Data analysis comprised review of researcher/teacher log and critical friends transcriptions where patterns of successes and challenges were noted, and a final critical friends meeting where analyses were compared. Three major patterns were found: overwhelmed by technology, Zoom, and lack of faculty support, Glad to be in person, Exhaustion. The faculty member likened the experience to being a first year teacher, with doing her best against the unfamiliar and unknown, being persistent and confident in trying to work through issues. Recommendations are to develop classroom communities, as we were all going through Covid 19 together, faculty and students, provide faculty support for pedagogy in multiple formats, faculty members should maintain up to date technology skills, and remain persistent and confident, and develop a support group of others in the same situations.

Strand 7: Pre-service Science Teacher Education

Preparing Pre-Service Chemistry Teachers to Teach STEM Skills in Chemistry Classes

Aviva Klieger*, Beit Berl College, Israel
Tamar Yaron, Beit Berl College, Israel

ABSTRACT
21st century skills express the competencies that today's graduates need to hold a successful career. Seven 21st century skills that promote excellence in STEM were identified. Today's job market emphasizes the need for cooperation and teamwork to handle complex tasks. We have demonstrated how, through the encounter with the industry, pre-service chemistry teachers became aware of STEM skills especially teamwork skills and they practiced their implementation in chemistry classroom. Before they learned about the skills, they couldn't explain what teamwork is beyond group work. We found reference to components of teamwork in their reflections after their experience in the industry. After performing PBL activity in the classroom we found more detailed references to teamwork. The pre-service chemistry teachers constructed a rubric that was compared to other two formal rubrics according to three core competencies: Components Management of conflicts, Teamwork and communication and Management of interpersonal relations. All rubrics emphasized the core competency: teamwork and communication, while the pre-service teachers ' rubric contained the smallest number of components. Comparison of the rubrics revealed that being aware is not enough. Development of teamwork competencies requires explicitly designed teaching and opportunities such as problem-based learning, group discussion, escape rooms and peer instruction.

Concurrent Session 3, 4/19/23, 8:25-9:55

A Science Teacher Looks in the Mirror
Kady Lane*, Indiana University, USA

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

ABSTRACT
Research provides evidence of a middle-class advantage in schools. The educational level and income level of parents are the largest predictors of student success in school (Duncan et al. 1998, Reardon 2011). Students from higher privileged families tend to receive higher grades and test scores, go further in school, find more stable employment, and earn more than those from less privileged families (Calarco 2018).
Instruction needs to be modified to meet all learners where they currently are, because every learner has different strengths. According to Akerson et al. (2014 p.6), "Learner needs can differ depending on socioeconomic status." This is just one reason why all teachers need to know who their students really are as individuals.
According to Alan et al. (2021) critical friends help provide rigor and trustworthiness in research this strengthens the research process. Key to a critical friend relationship is dialog, not just talk (Alan et al. 2021) and to have this you need to find someone that you respect and who respects you.

As a result of this work the two single most effective strategic changes I made was to slow down the pace of the lesson and offer time during the lesson for reflection.

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set: Data and Investigations in Scientific Inquiry
4/19/23, 8:25-9:55, Salon C7-8 (LL)

Promoting students' writing in the context of scientific inquiry
Jan-Martin Österlein*, University of Duisburg-Essen, Germany
Mathias Ropohl, University of Duisburg-Essen, Germany
Sebastian Habig, University of Erlangen-Nuremberg, Germany
Miriam Morek, University of Duisburg-Essen, Germany

ABSTRACT
In terms of writing in science class, writing to learn and learning to write can be distinguished. While writing to learn approaches use writing as epistemic tool for learning, learning to write focusses on the characteristics of scientific language to help students write better scientific texts. However, learning to write is criticized to only have little effects on students' learning and to not be embedded into the inquiry process. This PhD project seeks to investigate the effects of different instructional support with varying degrees of writing to learn and learning to write respectively. The instructional support is evaluated regarding its effects on the students' lab report writing proficiency and their content knowledge development using an experimental pre-post intervention test design. First results indicate that students at the pre-test have difficulties with linking different sections of the lab report. For example, if students describe their

observations or draw inferences from their observations, only few address which procedure preceded their observation or which observation they draw their inference from. Consequently, proper linguistic links between those parts of the lab report are rarely found. Next, evaluation will focus on developments regarding students' writing proficiency between pre- and post-test using variance analyses (MANOVA).

Balancing Authenticity and Personal Relevance of Science Through Student-Driven Neuroscience Investigations

Ido Davidesco, University of Connecticut, USA
Steven Azeka, Columbia University Teachers College, USA
Jimmy Couzens, University of Worcester, United Kingdom
Eric Loken, University of Connecticut, USA
Steven Carter, Columbia University, USA
Emma Laurent, Harvard University, USA
Henry Valk, Pison Technology, Inc, USA
Suzanne Dikker, New York University, USA
Wendy Suzuki, New York University, USA
Sarah Gilmore, University of Connecticut, USA

ABSTRACT
In science education, there is a potential tension between authenticity and personal relevance: what is significant to science disciplines is not necessarily personally relevant to students. Here, we explored to what extent students' investigations of their own brain and behavior could balance authenticity and personal relevance. In a new high school neuroscience curriculum, students used low-cost, portable Electroencephalography (EEG) technology to measure their brain activity and developed investigations related to their brain and behavior (e.g., "how does listening to music affect learning?"). We conducted semi-structured interviews with students and teachers in 13 public schools that implemented the curriculum. These interviews suggested that students perceived their science investigations as both authentic and personally relevant. These findings suggest that the collection and analysis of students' own brain and behavior data can effectively engage students in the practices of science.

A Comparison of Undergraduate Students' Thinking about Carbon Cycling in Trees Using a Picture Walk

Rebecca Krall*, University of Kentucky, USA
Katherine Sharp*, Stephens College, USA
Sagan Goodpaster, University of Kentucky, USA
Moria Peel, University of Kentucky, USA
Amber Keene, University of Kentucky, USA

ABSTRACT
Considering global climate change and the greater focus on alternative energy sources, understanding energy flow through an ecosystem, particularly photosynthesis and respiration, is essential. Previous studies have reported conceptual gaps in K-12 and college students'

understandings of the basic needs of plants. The purpose of this study was to explore how a semi-structured interview protocol designed around a series of pictures of trees in temperate forest environments and in summer in a far northern locale above the 60° N could inspire college students from diverse majors (science and non-science) to construct explanations about sources of energy for deciduous trees. Natural environments of trees were used in this study because of their commonness in students' everyday lives. A constant comparative method using inductive coding was used to analyze the data. The findings illustrate how students attempted to apply knowledge learned from formal and informal learning experiences and through analogies constructed about their own bodies to make sense of the energy sources for trees in each location and how trees access that energy for life processes. Fragmented understandings were demonstrated by all the traditional undergraduates interviewed, illustrating a possible outcome of study skills students may utilize in learning concepts.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set: Rethinking Epistemic Agency: Examining tensions and perspectives among scholars, teachers, and students
4/19/23, 8:25-9:55, Salon C1-2 (LL)

Do we have the same definition? Variations in published transcripts showcasing students' epistemic agency

Christina Krist*, University of Illinois Urbana-Champaign, USA
Nitasha Mathayas, Indiana University Bloomington, USA

ABSTRACT
This study explored how "epistemic agency" is being functionally defined by the science education community. We first conducted a systematic literature review for papers that contained "epistemic agency" in either the abstract or the title (indicating that epistemic agency was a substantive focus of either the analysis or claims) and also contained "science education" somewhere in the text. This search generated 27 items. Thirteen of those articles contained published transcript excerpts. We re-coded those transcripts excerpts using the grammar of agency (Martin, 2016), an analytical tool based on discursive psychology and positioning theory using linguistic features to identify how responsibility is being indexed, by whom, to whom. These features provide microgenetic insight into how ideas and actions are being shaped, and by whom, during science discussions. Initial findings showed variations in pronoun use and verb modality across episodes that took place during similar activity structures. These differences suggest there may be important variations in epistemic agency when there is a lack of explicit disagreement. In addition, students linguistically indexed responsibility to scientists and mechanistic entities, suggesting that attending to socio-material dimensions may be important for continuing to sharpen our analytic understanding of epistemic agency.

What do Different Figured Worlds Mean for Epistemic Agency in Science Class?

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
In this study, we explore the various figured worlds students and teachers have regarding science classrooms. Our primary focus is on the roles and responsibilities teachers and students have for themselves and one another as a way of understanding the potentially different expectations teachers and students have for students to act as epistemic agents in science class. We code teacher and student reflective interviews across a unit for evidence of how each describes the role of both students and teachers. Variation in these expectations influence the ways students react to their teachers' efforts to enact practice-oriented reforms as well as the ways students contribute to class. Results show that the teacher repeatedly invites students to act as epistemic agents. However, the extent of this agency seems to be mismatched between teacher and student expectations. The students see their roles including tasks such as asking questions and exploring potential answers through investigation, but they see their teacher's role as providing correct and complete knowledge of science ideas by the end of the unit. Differential expectations such as these show how students may need greater support to adjust to new roles and responsibilities in order to more fully exercise epistemic agency.

Conceptualizing teacher learning for supporting students' epistemic agency in science as an ideological process

Mon-Lin Monica Ko*, University of Illinois Chicago, USA
Christina Krist*, University of Illinois Urbana Champaigne, USA
Barbara Hug*, University of Illinois Urbana Champaigne, USA
Nessrine Machaka, University of Illinois Urbana Champaigne, USA

ABSTRACT
This paper examines what "counts" as epistemic agency (EA) in the context of enacting NGSS-aligned storyline curriculum materials. We designed and facilitated a 4-day professional development (PD) workshop to support teachers in interpreting and modifying their curriculum materials with a goal towards supporting students' EA. Over the 4 days, we engaged in two streams of activity: 1) an analysis of 3 video cases (teachers' enactments) of NGSS-aligned curriculum materials to identify how teachers opened up space to amplify student's EA, and 2) identifying activities and lessons in the units the participants planned to enact in the following semester to create more opportunities to promote EA. We analyzed both the whole group discussions and the individual teacher journals and found that the discussions around EA shifted over the course of the PD, from a focus on teacher facilitation and adaptations that veered away from the existing storyline to thinking about the contested nature of negotiating

agency with students. We also found variability across individual teacher participants in how they positioned themselves, curriculum materials, and their students in relation to one another in efforts to promote EA during curriculum enactment.

How teachers' high-level goals related to supporting student epistemic agency change during professional learning

Cynthia Passmore*, University of California, Davis, USA
Jason Buell, Northwestern University, USA
Jessica Alzen, University of Colorado Boulder, USA
Kelsey Edwards, Northwestern University, USA
Chris Griesemer, University of California, Davis, USA
William Penuel, University of Colorado Boulder, USA
Brian Reiser, Northwestern University, USA

ABSTRACT
We investigated how teachers in a year-long professional learning setting approached and made sense of instructional materials that have an explicit focus on creating the conditions for students to exercise epistemic agency in the classroom. We found that teacher goals at the outset of the professional learning program demonstrated a number ideas and intellectual resources that aligned to the vision of fostering student epistemic agency. As participation in the program deepened, we saw that their goals for themselves and their students narrowed and became more strategy-oriented in the context of professional learning around the design and enactment of instructional materials. Understanding how teachers' ideas shift over time as teachers learn about and enact curriculum can provide insight into fruitful ways to work with teachers to foster student epistemic agency in the classroom.

Using classroom artifacts to build epistemic agency over time

Jason Buell*, Northwestern University, USA
Jessica Alzen, University of Colorado Boulder, USA
Kelsey Edwards, 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
This paper presents a case study from a classroom of students who report high levels of what researchers call epistemic agency. We show how a classroom teacher was able to support epistemic agency through the shared creation, revision, and use of classroom artifacts. In this classroom, the teacher and students work together at every stage to publicly negotiate the creation and revision of classroom artifacts, such as consensus models and definitions on a word wall. We observe students, on their own and with the support of the teacher, mobilizing these artifacts during scientific discussions to help move their thinking forward. We argue that through the use of artifacts, we are observing how epistemic agency is not only emergent in

moment-to-moment interaction, but how it can build over time. We argue that classroom artifacts, in addition to being representation of students' ideas, can also be seen as representations of students' epistemic agency and that the shared creation and use of artifacts is an important space for investigation into how epistemic agency can build momentum over longer time periods and one way to do so is through the careful tracing of the creation and use of classroom artifacts.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Culturally Responsive and Inclusive STEM Instruction
4/19/23, 8:25-9:55, Salon A1 (LL)

Culturally Responsive Undergraduate Science Education (Cruse): A Pedagogical Training Framework for Academic Biology

Hillary Barron*, Bemidji State University, USA

ABSTRACT

Utilizing pedagogies of empowerment such as culturally responsive science teaching (CRST) in undergraduate classrooms can mitigate the gatekeeping phenomenon often seen in science. College biology educators (teaching assistants and faculty alike) engage in extensive one-on-one time with students, yet minimal pedagogical training is offered to them. Therefore, training for improved pedagogical knowledge is important for college biology educators, but training for culturally responsive science teaching is critical as such educators have broad and lasting impacts on students. Using constructivist grounded theory methods, this study explores the ways training for culturally responsive science teaching impacted educators of undergraduate biology courses. This study applied grounded theory methodology to develop a theoretical understanding of educators experience, and to create a pedagogical training framework. The resulting framework, Culturally Responsive Undergraduate Science Education (CRUSE) consists of three domains – Culturally Relevant Pedagogy, Funds of Knowledge, and Social Justice Science Issues – that all center around creating positive science learning experiences for students that promote a rightful presence for all students.

A Framework for Equitable, Student-centered Undergraduate STEM Instruction

Daniel Hanley*, Western Washington University, USA
Shannon Warren, Western Washington University, USA
Dustin Van Orman*, Western Washington University, USA
Xyan Neider, Whatcom Community College, USA
Alyssa Cavazos, University of Texas- Rio Grande Valley, USA
Shevell Thibou, Western Washington University, USA

ABSTRACT

Uses of research-based instructional strategies in STEM higher education— equitable, inclusive, active, and student-centered— support all students' learning and the future potential for all students, particularly systematically non-dominant minoritized students. However,

traditional classroom and institutional structures remain commonplace in institutions of higher education worldwide— characterized, in part, by overemphasis on lectures to deliver content, high-stakes summative assessments that prioritize the memorization of facts, and limited opportunity for communication between and among students and instructors. In this proposal, we describe the impetus, development, and uses of an equitable, student-centered framework for STEM teaching and learning that can contribute to reforms in higher education. We present the framework and our long-term development and research plans to enact and examine instructional and institutional change.

Learning from the Past; Building a Framework of Physics Identity

Alia Hamdan*, University of Arizona, USA
Sanlyn Buxner, University of Arizona, USA

ABSTRACT

This theoretical paper aims to summarize past research that discusses science identity. Studies from the last 20 years were identified and then narrowed down to focus on physics identity. Identity has become a growing field in disciple-based education research (DBER). Through this work, three scales were identified to navigate the different elements to focus on; the unit of analysis, theoretical origins, and choice of focusing on differences or similarities in student identities. With the aforementioned scales, we shifted through the research and categorized papers based on where they best fit. For the physics identity framework explained in this paper, we use an individual as the unit of analysis, taking both individual agency and structural mechanisms into account. The physics identity framework outlined here is composed of four main factors, Recognition, Performance/Competence, Interest, & Sense of belonging. This literature review and framework can be used as a starting point for teachers and early career researchers who are interested in identity work. It also provides a framework for researchers to think about how they define identity within these larger scales and will be useful in building a foundation to map the knowledge as the field expands.

Investigating Active Learning and Inclusive Practices in Introductory College Science Courses

Mojtaba Khajeloo*, University of Nebraska Lincoln, USA
Deepika Menon, University of Nebraska Lincoln, USA
Deef Allah Al Shorman, University of Nebraska Lincoln, USA

ABSTRACT

Active learning and inclusive teaching practices have been proposed as effective pedagogical approaches to increase students' learning and decrease achievement gaps among the diverse student populations. But question remains how active learning practices are inclusive of all students. In this regard, we have tried to characterized an introductory science course through the lens of active learning practices, and then investigate the ways it was inclusive of all students through theoretical framework of Universal Design for Learning (UDL). To this end, we did a case study on an introductory science course by drawing on various data sources like pre-semester and post-semester interviews, classroom video recodings and field notes, course curriculum and student interviews. We found that in designing the course and deciding about her teaching practices, our participant instructor was primarily focused on engaging students

with the course content and involving them in their own learning through active learning strategies. We also found her practicing inclusive teaching. However, such practices were more a by-product of active learning practices and less a major and explicit goal of the course.

Strand 6: Science Learning in Informal Contexts
Symposium: Once upon a time… The use of narratives in informal learning environments
4/19/23, 8:25-9:55, PDR 2 (L3)

Once upon a time… The use of narratives in informal learning environments

Neta Shaby*, University of Southampton, United Kingdom
Orit Ben Zvi Assaraf*, Ben Gurion University of the Negev, Israel
Maya Barzilay, Ben Gurion University of the Negev, Israel
Palmyre Pierroux*, University of Oslo, Norway
Rolf Steier, OsloMet University, Norway
Ran Peleg*, University of Southampton, United Kingdom
Muriel Grenon, National University of Ireland Galway, Ireland
Scott Pattison*, TERC, USA
Gina Svarovsky, University of Notre Dame, USA
Justin Dillon, University College London, United Kingdom

ABSTRACT
People use stories as a way to communicate with each other and a way to understand the world around us. Everyday conversations, movies, books and television are filled with storytelling. Narratives are believed to facilitate information processing and memory by increasing interest, relevance, and attention. Due to the educational benefits narratives are presumed to promote, many scholars have argued for greater use of narratives in science education and as a tool to make science accessible to the public.

Research on narratives-based pedagogy in science education and communication is common. However, most research was done with school (or pre-school) children in formal settings. In this symposium, we would explore the use of narrative in informal science environments, using narrative-based pedagogy to communicate science to various participants/audience and explore the ways narratives can potentially support and facilitate science learning, engagement, and understanding.

In this symposium, we present five studies examining narratives in the context of STEM learning in informal settings: science museum, zoo, virtual exhibition, escape room, and home-based engineering activities. The studies look at variety of participants in these settings, including elementary and high school students, free-choice visitors, and preschool-age children and their families.

Strand 7: Pre-service Science Teacher Education
Related Paper Set: Operationalizing Justice-Centered Science Education By Teaching Through Science and Engineering Practices
4/19/23, 8:25-9:55, Salon A4 (LL)

Planning Enacting and Reflecting Science and Engineering Practices in K-5 Classrooms: Towards Justice-Oriented Science Teaching
Meenakshi Sharma*, Mercer University, USA

ABSTRACT
The current study examines K-5 in-service teachers' enactment and reflection of their instruction grounded in science and engineering practices (SEPs) in their own classrooms . The primary data involved teachers' instructional videos, and their written reflections which critiqued these videos using designated codes . We used the idea of teacher noticing (Walkoe, Sherin, & Elby, 2020 and examined teaching moments identified by the teachers using the codes provided to them for analysis. These moments were studied to answer the question, "How are students positioned during science lessons in which teachers make efforts to implement SEPs?" Teachers had varying levels of success in implementing SEPs. Teachers who enacted SEPs to an extent took encouraging steps towards justice-focused equitable science teaching. They asked open-ended discussion based questions, making science potentially accessible to all students and positioning them to share their ideas and lived experiences about phenomena. However, teachers did continue to fall back into emphasizing vocabulary and canonical science knowledge. In-service teachers need continuous support to develop a deeper understanding of SEPs as well as rubrics to help them assess their own planning, enactments, and student engagement with SEPs in a more nuanced way to support equitable science instruction that is justice focused.

Elementary Preservice Teachers' Becomings Towards Equitable and Inclusive Science Teaching
Sophia Jeong*, The Ohio State University, USA

ABSTRACT
The current study aims to operationalize the notion of equity that provokes elementary pre-service teachers (PSTs) of science to ask multiple questions and engage in critical inquiry into justice-focused, equitable and inclusive science teaching and learning. To that end, drawing on posthumanism as a theoretical framework, the purpose of this study is to examine the process by which elementary PSTs of science construct their understanding of justice-focused, equitable science teaching as they interact with actors in an assemblage of which they are part. PSTs were able to consider reimaginings and diverse ways of equitable and inclusive teaching. Rhizomatic analysis employed in this study helped reimagine these possibilities.

Pre-service Science Teachers of Color: Connecting the NGSS Practices with Justice-Centered Science Pedagogy
Valerie Valdez*, Stevenson University, USA
Matthew Bennett, University of California, Santa Barbara, USA

Royce Olarte, University of California, Santa Barbara, USA
Cameron Dexter Torti, University of California, Santa Barbara, USA
Donald McNish, University of California Santa Barbara, USA
Liliana Garcia, University of California, Santa Barbara, USA
Sarah Roberts, University of California, Santa Barbara, USA
Julie Bianchini, University of California, Santa Barbara, USA

ABSTRACT
A justice-centered science teacher education requires pre-service teachers to plan instruction around authentic and community-based problems, give students a critical lens through which they may critique inequitable and racist systems, and teach students ways they can enact change to contribute to creating a more equitable society (Morales-Doyle, 2017). To better understand how to support teacher learning about justice-centered science pedagogy, we used a case study design to investigate the ways PSTs of color discussed the SEPs as not only connected to academics, but to social justice science issues and students as producers of knowledge. From our qualitative analysis of interviews, we found preservice teachers reported attending to high academic expectations using the NGSS, scaffolds, and ambitious science teaching. They also framed students as producers of knowledge and culture by developing student relationships and building from students' ideas. Most PSTs shared that their teacher education courses taught them about social justice and/or culturally sustaining pedagogy, but provided few connections to the SEPs and implementation in placement classrooms. Findings from this study underscore the need to prioritize the integration of social justice science issues into science teacher education programs so as to prepare preservice teachers to fully enact justice-centered science teaching.

Working to Hear Diverse Ways of Knowing: Development of Skills for Enacting Justice-Centered Science Pedagogy

Tierney Hinman*, Auburn University, USA
Alison Mercier, University of Wyoming, USA

ABSTRACT
One of the tenets of justice-centered science pedagogy is centering students as transformative intellectuals. This calls on teachers to notice, support, and value students' diverse ways of knowing and sensemaking repertoires while engaging students in understanding how their own community histories, values, and practices contribute to scientific understanding. To better understand how to support pre-service teachers' (PSTs) learning about and implementation of equity- and justice-focused science pedagogy in elementary classrooms, we explored the ways in which PSTs framed elementary students' explanations of scientific phenomena and noticed (attended to, listened to, and thought about) students' diverse sensemaking. We found that PSTs were framing students' explanation in ways that could be considered along a spectrum of more narrow to more expansive. When provided opportunities to develop the ability to recognize and value students' diverse sensemaking repertoires, all PSTs framed students' scientific explanations more expansively over time, positioning them to be able to enact justice-centered science pedagogy in their future classrooms.

Concurrent Session 3, 4/19/23, 8:25-9:55

Symmetry in Learning: Using Methods Courses to Model Justice-centered Science Education Approaches for Pre-service Teachers

David Steele*, Alder Graduate School of Education, USA

ABSTRACT

Enacting a justice-centered science education requires teachers to: a) develop an analysis of oppressive manifestations in society (Diemer and Rapa., 2016), b) see themselves as capable of enacting transformational change (Rapa et al., 2022, Seider et al., 2019), and c) create opportunities for students to engage in learning that positions them as transformative intellectuals capable of leading social transformation (Duncan-Andrade and Morrell, 2008; Morales-Doyle, 2017).

This paper explores how teacher preparation programs might prepare PSTs to enact such an approach. Data was collected from secondary science methods courses during the 2021-2022 academic year. A key premise of the courses was symmetry in teacher learning, which Mehta and Fine (2019) describe as "giving adults opportunities to learn in ways that parallel how students learn" (p. 484). Sixty total lesson plans and teaching videos were analyzed as data sources (15 for each assignment; October, November, January, and February).

Evidence supported the following themes: 1) residents engaged students in high quality science lessons through SEPs, 2) residents provided K-12 students with opportunities to explore community related phenomena, but phenomena were not always rooted in social justice issues, and 3) residents struggled to provide students opportunities to be seen as transformative intellectuals.

Strand 7: Pre-service Science Teacher Education

SC-Organized Paper Set: Approaches of Preservice Teachers Developing Self-efficacy & Motivation for Science Learning and Teaching

4/19/23, 8:25-9:55, Waldorf (L3)

Elementary PSTs' summer field experience: Developing self-efficacy and science best practices

Jacquelyn Duran*, Teachers College, USA
Alison Matthews*, Teachers College, USA
Minjung Lee, Old Dominion University, USA
Allison Bookbinder, Teachers College, USA

ABSTRACT

At a time when we are reflecting on scientific literacy and the need for reform, there is an ongoing need to improve elementary science education and continue the search for the best ways to prepare preservice elementary teachers (PSTs) to teach science in their future classrooms. Elementary teachers still struggle with teaching science when faced with the realities of their classrooms, such as math and literacy taking priority and lacking science instructional resources. Authentic field experiences in which PSTs teach science may provide opportunities for PSTs to feel prepared to teach science once they enter their own classrooms.

Our study examines the ways in which a unique context of teaching science during a month-long, intensive, summer science program can help prepare PSTs to teach science. This paper will dive deeply into one aspect of the data, participants' perceptions of "good science teaching" before and after participating in the program, and will examine the relationship between these perceptions and participants' self-efficacy as measured by the STEBI-B. These findings have implications for reforming how we evaluate fieldwork in science teacher preparation programs.

The Effects of Work and Academic Experiences on Paraeducator Preservice Teachers' Science Teaching Self-Efficacy

Lindsay Lightner*, Washington State University, USA

ABSTRACT

Paraeducators show promise as a source of teachers with school-based work experiences and sociocultural community knowledge. However, less is known regarding the roles that these experiences and backgrounds may play in their teaching. This study investigates the effects that prior work and academic experiences have on paraeducators' abilities to create effective classroom environments as future teachers, as indicated by their general teaching self-efficacy and science teaching self-efficacy. Forty-three participants from a Grow Your Own paraeducator-to-teacher program completed two surveys and a demographic questionnaire at the program's start. Multiple regression analyses indicated that years of school-based work experience did not predict their general teaching self-efficacy. Regression analyses also indicated that a significant proportion of participants' science teaching self-efficacy was predicted negatively by their years of work experience and positively by their number of college science courses passed. Further, the participants' science teaching self-efficacy was predicted by their self-efficacy for student engagement. Teacher candidates with school-based work experiences should be given opportunities to leverage their student engagement self-efficacy when learning to teach, and to build instructional self-efficacy by teaching outside their past work experience areas. Likewise, traditional preservice teachers may benefit from opportunities to build their student engagement self-efficacy.

Pre-service biology teachers' development of research competence and motivation affected by (non-)restrictive learning opportunities

Lea Gussen*, Institute for Biology Education, Faculty of Mathematics and Natural Sciences, University of Cologne, Germany
Fabian Schumacher, Center for Teaching and Learning (ZLL) / University Teaching and Instructional Development, Bielefeld University, Germany
Laura Ferreira González, Chair of Educational Support and Social-Emotional Development, Department of Special Education and Rehabilitation, Faculty of Human Sciences, University of Cologne, Germany
Kirsten Schlüter, Institute for Biology Education, Faculty of Mathematics and Natural Sciences, University of Cologne, Germany
Jörg Großschedl, Institute for Biology Education, Faculty of Mathematics and Natural Sciences, University of Cologne, Germany

ABSTRACT
Research competence, consisting of affective-motivational and cognitive abilities, enables teachers to interpret research and reflect on their teaching. Inquiry-based learning is a well-established method of promoting research competence. The degree of autonomy in inquiry-based learning seems to be a potential factor influencing learning outcome. How structuring or openness of the individual learning paths affects the development of research competence is unclear. As part of an inquiry-based learning course, we conducted an experimental intervention study with online learning modules providing research methods information. The treatment group could only proceed to the following sequence after mastering the previous one. The control group was free to choose their learning path. Results show that the affective-motivational ability decreased and the cognitive ability increased in both groups over the course (pre-posttest). In research methodology knowledge, the treatment group scored higher. No differences were found in intrinsic motivation among groups and measurement points. Although autonomy was restricted, there was no effect on motivation, but a positive effect on knowledge.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Strengthening Science Teachers' NGSS-Aligned Instruction by Focusing on Students
4/19/23, 8:25-9:55, Salon C5-6 (LL)

Building on Students' Assets in Science and Engineering Classrooms
Selcen Guzey*, Purdue University, USA
Khanh Tran*, Purdue University, USA
Soo Won Shim*, Purdue University, USA
William Walker*, Purdue University, USA
Sedef Cabazoglu Bilici, Gazi University, Turkey

ABSTRACT
Research on diversity and equity in science education has primarily focused on urban students, while mostly ignoring distinct challenges teachers and students face in rural settings. In this study, five middle school teachers from rural areas participated in a year-long professional development (PD) program focused on asset-based approaches and curriculum materials. Pre and post-test data were collected from over 550 students over two years, before and after the PD. There was significant effect of the use of asset-based pedagogies on student post-test scores after accounting pre-assessment.

Science Teachers' Assessment Strategies of their Students' Models
Alexis Gonzalez, University of British Columbia, Canada
Samia Khan*, University of British Columbia, Canada

ABSTRACT
The overarching research objective is to explore how in-service science teachers (ISTs)' assessment literacy in practice shapes their pedagogy when teaching with models (MBT). This research is significant because over the last decade many studies have focused on measuring students' understanding of models but there is still a lack of studies on how ISTs develop and implement strategies to assess students' models. Also, teachers are pivotal in facilitating the revision and modification of models, and they do so by assessing their students. This study showed that ISTs possess limited repertoire to assess students' generated models and modeling practices and often teach and assess pre-defined models. We identified that when a teacher is more literate in assessment in MBT, s/he can implement a wider variety and more often strategies to promote the evaluation and modification of models in comparison to less literate ISTs.
This study is significant because the results offer a better understanding of the underpinnings of assessment literacy of science teachers in MBT, and the results might be useful for stakeholders in science education and especially for curriculum developers, many of whom must consider teachers' preparedness for MBT.

Make Graphs? A Survey of Teachers on How Their Students Analyze and Interpret Data
Omiya Sultana*, University of Tennessee, USA
Joshua Rosenberg, University of Tennessee, USA
Elizabeth Schultheis, Michigan State University, USA
Melissa Kjelvik, Michigan State University, USA
Aaron Reedy, Data CLassroom, USA

ABSTRACT
For science education, the Framework for K-12 science education requires students to have opportunities to learn the standard data analyzing and interpreting techniques. Knowing about the types of activities teachers do (and the challenges they face) is important given the wide range of ways students might analyze and interpret data, from collecting and interpreting relatively small data sets to engage in sophisticated visualizations of large-scale, even messy data sets. In our previous paper (Authors, 2022), we explored the sources of data students and teachers use in science classrooms. The purpose of this study is to explore common data practice activities and possible challenges for data practice activity in the science classroom. We have conducted a survey research methodology. We found that data visualization and data interpretation is the most common activity that students engage in in a science classroom. Evaluating data and trustworthiness is the most reported challenge reported by educators.

Teacher-driven Adaptations: Seeding Productive Uncertainty and Moving Toward Equity-Oriented Practices
Emily Adah Miller, University of Georgia, USA
Susan Kelly*, Michigan State University, USA
Selin Akgun, Michigan State University, USA

ABSTRACT
The NGSS spurred a curriculum movement that enabled elementary teachers to enact shifts in science learning while adapting curriculum to address the needs and diverse resources of their students. This paper presents the voices of teachers and their experiences with lesson adaptation with a focus on their descriptions of uncertainty. Teachers expressed uncertainty about three themes, including challenges (time, structures, and technology), maintaining PBL features and meeting standards, and equity. With regard to making changes toward equity-oriented teaching, uncertainty often caused teachers to challenge previously held assumptions, which we define as productive uncertainty. Implications include that uncertainty can be productive for teachers, and the call for further research questions about designing curriculum and PL for productive uncertainty though encouraging adaptation.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set: Assessments to promote reform based science education
4/19/23, 8:25-9:55, Salon C3-4 (LL)

New NGSS-aligned Early Childhood Assessment Instrument: An Exploratory Rasch/IRT Analysis of theKinderSci

Christopher Wojciechowski*, University of Toledo, USA
Susanna Hapgood, University of Toledo, USA
Charlene Czerniak, University of Toledo, USA
Scott Molitor, University of Toledo, USA
Joan Kaderavek, University of Toledo, USA
Grant Wilson, University of Toledo, USA

ABSTRACT
This paper examines the pilot administration of an easy-to-administer NGSS-aligned assessment (KinderSci) for 4 – 6-year-olds. Building upon Science Learning Assessment items that were developed by Samarapungavan et al. (2009), the KinderSci consists of 26 multiple-choice questions that have been aligned with the K-12 Science Framework (2012) and the Next Generation Science Standards (2013). In addition to content-focused items, particular attention was given to developing items addressing science and engineering practices and cross-cutting concepts. The KinderSci was administered in the fall and/or spring in 11 preschool or kindergarten classrooms by teachers who were involved in a year-long science and engineering-instruction professional development initiative. Rasch analyses conducted on 71 administrations of all or at least half of the assessment supported an evaluation of the performance of the instrument, including recommended items of concern for examination in the development of the next iteration of the instrument. The evaluation of student data via Rasch analyses supports a paired t-test outcome indicating that, when accounting for item difficulty and missing data, there was a positive change in student outcomes between the pre-assessment and the post-assessment.

Measuring Claim-Evidence-Reasoning Using Scenario-based Assessments Grounded in Real-world Issues

William Romine*, Wright State University, USA
Ankita Agarwal, Wright State University, USA
Emily Burwell, Wright State University, USA
Maha Kareem, University of Missouri, USA
Amy Lannin, University of Missouri, USA

ABSTRACT
Improving students' use of argumentation is front and center in the increasing emphasis on scientific practice in K-12 Science and STEM programs. We explore the construct validity of scenario-based assessments of claim-evidence-reasoning (CER) and the structure of the CER construct and how middle school students progress along it. Establishing the purpose of an argument is a competency that a majority of middle school students meet, whereas quantitative reasoning is the most difficult. Semantically, a majority of the responses discuss the social issues and science concepts underlying the scenarios, while relatively few contain terms related to evidence processing and quantitative reasoning.

Assessing Data Practices in High School Science Courses

Peter Rich*, Brigham Young University, USA
Erin Peters-Burton, George Mason University, USA
Timothy Cleary, Rutgers University, USA
Anastasia Kitsantis, George Mason University, USA
Laura Laclede, George Mason University, USA
Jessica Yauney, Brigham Young University, USA
Connor Reynolds, Brigham Young University, USA

ABSTRACT
The use of data is central to scientific inquiry. Consequently, it is important that high school students learn to work with data, from conception to analysis to presentation. One way to accomplish this is through computational thinking, taking advantage of increasingly ubiquitous computational tools. In this study, we expanded on Weintrop et al.'s (2016) concept of data practices as they intersect with computational thinking. We describe the development and validation of a common assessment that can be used across biology, chemistry, Earth science, and physics to measure students' ability to computationally create, collect, manipulate, analyze and visualize data.

Development and evaluation of a competence test in organic chemistry at university level

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Carolin Eitemüller, University of Duisburg-Essen, Germany
Marc Rodemer, University of Duisburg-Essen, Germany
Maik Walpuski, University of Duisburg-Essen, Germany

ABSTRACT
The dropout rates of science courses at universities have been at a constantly high level in recent decades (Heublein et. al., 2020). For this reason, interest in developing and evaluating science education processes at the university level is increasing. One possibility to advance this evaluation can be seen in competence diagnostics, which is already successfully used in the school context (e.g., PISA, TIMSS) and whose potential can also be used in the university context. In the focus of this evaluation are test instruments that enable a valid and reliable measurement of competences.
In the project, a competence structure model for organic chemistry at university level was developed, which was operationalized through a suitable content knowledge test. The content knowledge test is examined regarding its fit to the Rasch-model. In addition to the model fit, the influence of the axes of the competence model on the task difficulty is determined.
The results show a good fit to the Rasch-model ($0.83 \leq wMNSQ \leq 1.24$; $-2.49 \leq t \leq 4.15$) as well as a high person separation reliability of 0.8. In terms of task difficulty, the dimensions of the competence model can explain 43 % of the measured variance.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Breaking Barriers: Broadening the Contextualization of Science Pedagogies and Professional Development
4/19/23, 8:25-9:55, Salon A2 (LL)

Declining Achievement in STEM Gasping for Breath –Longitudinal Study of Choking Impact of Culturo-Techno-Contextual Approach

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Juma Shabani, University of Burundi, Burundi
Adekunle Oladejo, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Ibukunolu Ademola, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
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Olasunkanmi Gbeleyi, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Franklin Onowugbeda, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Fred Awaah, University of Professional Studies, Ghana
Rose Agholor, STEM International Research Group, Nigeria
Angela Irene, National Universities Commission, Nigeria
Ibiyinka Ogunlade, University of Ado-Ekiti, Nigeria

ABSTRACT
Studies narrowing on culture and science learning alone will give us small victory in the quest to improve students' performance in science. Culture laced with context and technology has greater potential to "blast the armour" hindering students' better performance in science. This study examined the impact of a combo curriculum delivery "armament" - the culturo-techno-contextual approach (CTCA) on students' performance in science in a three-year longitudinal study. The study proceeded in two phases- survey and quasi-experiment. A total of 1,292 students participated in the survey phase. The quasi-experimental phase had 1,454 senior secondary class 2 students. The STEM subjects tested were biology, chemistry, physics, mathematics, and ICT. Treatment ranged from three to eight weeks. In the two biology studies, the experimental group taught using CTCA outperformed the control. This pattern of results was found for the two chemistry studies; the three studies in ICT; and the studies in mathematics and physics. The qualitative data obtained through student interviews showed unanimous confirmation of CTCA easing the difficulty in learning the difficult topics. Within the limitations of the study, CTCA was recommended as worth implementing if the goal is to break barriers to students learning of STEM.

Combating Students' Anxiety and Promoting Meaningful Learning of Computer Networking: Should we trust CTCA?

Esther Peter*, 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
David Peter, Lagos State University, Nigeria
Deborah Agbanimu, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Franklin Onowugbeda, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Olasunkanmi Gbeleyi, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Sue Dale Tunnicliffe, University College London, United Kingdom
Fred Awaah, University of Professional Studies, Ghana
Adekunle Oladejo, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Ibukunolu Ademola, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Fiacre Muhimpundu, Universite du Burundi, Burundi

ABSTRACT
Anxiety is a basic human emotion that consists of fear and uncertainty. It must be reduced in classrooms so as to win students to study computer studies and other science subjects. The focus of this study is to explore the efficacy of culturo-techno-contextual approach (CTCA) in reducing the anxiety level of students and promoting meaningful learning of computer networking. The study adopted an explanatory sequential mixed method design whereby quantitative and qualitative data were gathered. The experimental class had 62 subjects while

the control group had 57 subjects of junior secondary school 2 (equivalent of 8th grade) computer studies students in Lagos State, Nigeria. Quantitative data were collected through the computer networking anxiety scale and achievement test with respectable instrument measures. The experimental group was taught using culture-techno-contextual approach while the control had their learning experiences through the lecture method. The descriptive statistics showed that the experimental group outperformed the control group with the mean anxiety scores (experimental=15.87; control=16.98) and mean achievement (experimental= 15.79; control=12.21). The results showed that CTCA can be trusted as a teaching method that promotes meaningful learning and reduces the anxiety level of students in computer studies.

Socio-Scientific Modeling as an Approach Towards Equitable Modeling

Rebecca Lesnefsky*, University of North Carolina, USA
Eric Kirk, University of North Carolina, USA
Troy Sadler, University of North Carolina, USA
Li Ke, University of North Carolina, USA
Jasmyne Yeldell, University of North Carolina, USA

ABSTRACT
Developing modeling competence has become one of the major goals in science education. Although the literature on how to best support students as they engage in modeling is extensive, concerns have recently been raised about the narrow conceptions of what counts as modeling (Author, XXXX). In response to this concern, socio-scientific modeling (SSM; Author, XXXX) has emerged as a tool to broaden the breadth of what may be legitimately incorporated into modeling in a way that values learners' histories, goals, and social context (Berland et al., 2016). Our study aims to expand how the science education community views modeling by providing evidence for ways SSM creates opportunities for students to engage with phenomena that are normally not available in scientific spaces. This paper will outline how the construction of socio-scientific models incorporates different ways of knowing to make the practice more equitable outside Western European cultures. We contend that SSM provides opportunities for students to draw from their areas of knowledge and expertise to examine the systems' behaviors and dimensions in a way that expresses personal meaning, sensemaking, and understanding that is normally not valued within the scope of traditional scientific models.

Talking STEM in the hallways: Professional development for engaging students in SSI and social justice

Lisa Marco-Bujosa*, Villanova University, USA
Becky Mathers-Lowery*, Arcadia Unversity, USA
Joseph Johnson*, Mercyhurst University, USA
Victoria Araco, Villanova University, USA

ABSTRACT
Despite decades of reform, inequities across race and class persist in STEM education. Transforming student opportunities to learn demands significant changes to teacher understandings of what it means to know and do science and math. This study was designed to explore how secondary urban STEM teachers transformed their instruction to simultaneously

address content standards through issues of social justice using socioscientific issues (SSI) and socio-transformative constructivism (sTc). A multiple case study methodology was employed to explore teacher experiences in the first year of an intensive two year professional development (PD) program in which teachers designed and taught their first unit. Data collected from four of the participating teachers included one observation of instruction, a post-observation interview, and an end of the year interview. Through a grounded analytic approach, teacher experiences included successes, notably increased student engagement, opportunities, including opportunities for their own learning; and barriers, reflected in restrictions to their teaching. The findings of this study have implications for teacher education and offer insight into the disciplinary and structural barriers teachers must overcome to transform student opportunities to learn.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Enacting Social Justice in Science and STEM Classrooms
4/19/23, 8:25-9:55, Salon A3 (LL)

STEM, Equity, and Justice: Trends from the last decade in science education research

Rachel Gisewhite*, University of Southern. Mississippi, USA
Fatlume Berisha, University of Prishitina "Hasan Prishtina", Albania
Hannah McDuffie, University of Southern Mississipi, USA

ABSTRACT
The past few years have presented us with a slew of life-altering and unforeseen personal and community-based circumstances that have also revealed a heightened awareness of global social inequities and justice. As a result, global education is undergoing a significant transformation. It is imperative to investigate gaps in the current research to move forward. While it is not universally acknowledged, it is emphasized that all educational improvement efforts should focus on achieving equity and justice for all. Science, Technology, Engineering and Math (STEM) education inequities between dominant and non-dominant populations have been an ongoing concern in science education. This systematic literature review aims to explore and examine the last decade of research in top quartile science education journals in the promotion of equity and social justice in STEM teaching and learning. Specifically, this paper identifies how equity and justice are defined and implemented through and with STEM teaching and learning as represented in the current science education research. The analysis highlights the need for increased focus on instructional strategies that use STEM to expand opportunities for equitable and just science participation. The paper explores and elaborates on educational implications and steps for future progress.

Strengthening visions of equity through science and math integration

Andrew Gilbert*, George Mason University, USA
Jennifer Suh, George Mason University, USA

ABSTRACT
This paper highlights an integration of previously separated Science and Math methods courses for elementary preservice teachers. The course instructors utilized STEM problem-based learning as a pathway into equity-based instruction. The main research questions focused on how preservice teachers STEM learning and teaching experiences translated to their vision of integrated practice as a lever for equity-based pedagogy, while embedded in a diverse elementary school context. We analyzed PST's course activities including reflections, unit planning, STEM teaching, and enactment of a school-wide STEM fair. Findings revealed that when preservice teachers reflected on their own experiences, as STEM learners, it provided meaningful insights for delivering equitable instruction for all learners and positively impacted their vision for the abilities of children typically marginalized in traditional classrooms. Implications for developing equitable practice that nurtures children's natural curiosity and drive to learn as well as possibilities for integrating science across STEM are discussed.

Investigating the Effects of an At-home, Justice-centered STEM Curriculum: A Pilot Study
Margaret Blanchard*, NC State University, USA
Karen Collier*, NC State University, USA
Donna Farland-Smith, The Ohio State University, USA
Ana-Marie Topliceanu, North Carolina State University, USA

ABSTRACT
This pilot study sought to address inequities in STEM access by mailing nonfiction trade books featuring the stories of real-life underrepresented minority STEM professionals and content-aligned STEM kits to homes of rural middle school students. The quasi-experimental design investigated student participation and whether prompts that explicitly addressed social justice constructs would lead to differential responses by students in the intervention group. The justice-centered science pedagogy framework of Morales-Doyle (2017) informed our survey prompts. Findings highlight the positive experiences of the students and suggest the importance of the materials selected rather than the prompts. Implications and lessons learned are discussed.

Culturally Responsive Early Science Education—Perceptions and Practices of Bedouin Minority Teachers
Ornit Spektor-Levy*, Bar Ilan University, Israel
Idit Shaul, Bar Ilan University, Israel

ABSTRACT
Studies have shown that students perceive science learning as unrelated to their everyday lives. Therefore, science teaching should be based on real-world, relevant situations, starting from early childhood. Yet, preschool (in this study 3-6 years of age) teachers believe they lack knowledge and self-confidence in science teaching. Cultural challenges are also a barrier to teaching science. Culturally responsive science education (CRSE) seems ideal for equality and narrowing chronic gaps in science achievements between non-indigenous and indigenous children worldwide and in the Bedouin minority in Israel, in particular. Therefore, our main

objectives were to reveal what are Bedouin preschool teachers' attitudes, actual practices in science teaching, and teachers' own curiosity and tendency to explore? To what extent they vary from non-Bedouin teachers? What are their dispositions regarding early CRSE? Participants included 506 teachers: 143 Bedouin teachers. Research tools included 4 questionnaires and in-depth interview with 17 Bedouin teachers. Results revealed Bedouin teachers implemented significantly less scientific and exploration activities. Interviews indicated clear need for support to implement CRSE. The outcomes of this study are relevant to other efforts around the world to narrow educational gaps between disadvantaged indigenous minorities and the main population, making a positive contribution to CRSE literature.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set: Extended Reality to Support Science Learning
4/19/23, 8:25-9:55, Blvd A (L2)

How Do Chemistry Students Bridge Macro-Micro Scale with Magnetic Models and Immersive Virtual Reality?

Dewi Ungu*, Curtin University, Australia
Mihye Won, Curtin University, Australia
David Treagust, Curtin University, Australia
Mauro Mocerino, Curtin University, Australia
Henry Matovu, Curtin University, Australia
Chin-Chung Tsai, National Taiwan Normal University, Taiwan
Roy Tasker, Western Sydney University, Australia

ABSTRACT
Students can explore 3D arrangements of molecules with magnetic models and immersive virtual reality. However, the affordances of each medium to support students' conceptualisation of natural phenomena are yet to be researched. In this study, we investigated how twenty pairs of students use magnetic models and immersive virtual reality to explain the formation of snowflakes. Students' conversations and actions were recorded and qualitatively analysed in relation to their conceptual discussions. With magnetic models, students felt the attractions/ repulsion between water molecules and created simple tetrahedral and ring structures. Nine pairs of students directly associated the simple structures with the six-fold symmetry of snowflakes without elaboration of massive 3D expansions of the structures. With immersive virtual reality, students gradually built a complex ice lattice from simple structures. Fourteen pairs of students were able to discuss the micro-macro scale gap and link basic concepts of hydrogen bonding, hexagonal symmetry, and bond strength in their explanations of snowflakes after immersive virtual reality. Immersive virtual reality offered more opportunities for the realisation of constructivist approaches to support students' conceptual explorations compared to magnetic models. Future studies may wish to explore the educational affordances of learning media in promoting students' chemistry learning.

Influence of an immersive virtual reality experience on students' understanding of the shape of snowflakes

Henry Matovu*, Curtin University, Australia
Won Mihye, Curtin University, Australia
David Treagust, Curtin University, Australia
Mauro Mocerino, Curtin University, Australia
Dewi Ungu, Curtin University, Australia
Chin-Chung Tsai, National Taiwan Normal University, Taiwan
Roy Tasker, University of Western Sydney, Australia

ABSTRACT
Chemistry concepts are often taught in a fragmented manner and separate from the contexts where they can be applied presenting difficulties for students to develop a coherent understanding of the chemistry involved. In this study, we used the context of snowflakes in IVR and investigated how students would integrate their prior understanding of chemistry concepts to explain the shape of snowflakes after a collaborative IVR experience. Participants were 34 university students with a good understanding of the concept of hydrogen bonds. Videos of pre-/post-interviews were analysed. Before IVR, some students (n=6) were not sure how to explain the six-fold symmetry in snowflakes while most (n = 22) imagined that water molecules branched out in 2D. After IVR, most students (n = 28) provided coherent explanations linking their knowledge of the structure, polarity, hydrogen bonding, and scale of water molecules to explain the six-fold symmetry of snowflakes. This study demonstrates that, using IVR, educators can support students to integrate and apply their knowledge of science concepts in relevant contexts to develop coherent understanding of observable phenomena, such as the shape of snowflakes. Science educators may wish to explore the potential of IVR in developing students' understanding of other phenomena.

Using Extended Reality Technologies Within a Socioscientific Issues Unit on Climate Change

Mark Newton*, East Carolina University, USA
Len Annetta*, East Carolina University, USA
Denise Bressler*, Educational Testing Services, USA

ABSTRACT
This study uses Epistemic Network Analysis (ENA) to examine the use of Extended Reality technologies embedded in two different post-secondary climate change SSI units. One group used a virtual reality application on their smartphones in a traditional class setting to explore four different locations on the Outer Banks of North Carolina, USA. A second group used an augmented reality application on their smartphones while visiting the same four locations. Qualitative data was collected after each experience. Analysis of each group's networks indicated that both forms of technology engaged students in the SSI and were beneficial to their learning. However, differences in the networks revealed that virtual reality students made statistically stronger connections between the technology, the physical impacts of climate change, and the political/socioeconomic aspects of climate change. In contrast, the augmented reality students made stronger connections between the technology and learning in general. Furthermore, students who used augmented reality at the Outer Banks experienced

the virtual reality after visiting the area compared their actual experiences with the virtual reality experience.

Social Interactions in Immersive Virtual Reality: How Students Negotiate and Contribute to Learn Science

Mihye Won*, Curtin University, Australia
Henry Matovu, Curtin University, Australia
Dewi Ungu, Curtin University, Australia
David Treagust, Curtin University, Australia
Chin-Chung Tsai, National Taiwan Normal University, Taiwan
Mauro Mocerino, Curtin University, Australia
Roy Tasker, Western Sydney University, Australia

ABSTRACT
Immersive virtual reality offers a unique and compelling opportunity for students to interact and learn with peers in 3D virtual environments, but limited studies investigated students' collaborative interactions in immersive virtual reality. This study investigates how students negotiate and establish their social relations in a new virtual environment as they learn fundamental chemistry concepts-intermolecular forces of water molecules.

Strand 14: Environmental Education and Sustainability
Related Paper Set: Preparing for a warming world: Modeling and promoting climate literacy
4/19/23, 8:25-9:55, Blvd C (L2)

What is needed? Investigating drivers for students' climate-friendly intentions to act

Carola Garrecht*, IPN – Leibniz-Institute for Science and Mathematics Education, Germany
Jesper Haglund, Karlstad University, Sweden
Ute Harms, IPN – Leibniz-Institute for Science and Mathematics Education, Germany

ABSTRACT
Climate change is one of the greatest challenges of our time, and its consequences pose a severe threat to life on Earth. To address these challenges in the long term, we must adapt our behavior by making informed, climate-friendly decisions. In this regard, a growing body of research emphasizes the role of science education in fostering students' climate literacy. Drawing on a sample of 1276 upper-secondary students from Germany and Sweden, this questionnaire study investigates the role of climate literacy (i.e., knowledge, skills, and attitudes) as well as students' risk perception and value orientations in their climate-friendly intentions to act. Applying the method of sequential regression analysis, the results of our data analysis indicate that risk perception appears to be a key variable in explaining students' climate-friendly intentions to act. Cognitive factors (i.e., knowledge and skills) are also relevant to students' intentions, although less influential. For science education, the findings suggest that it may not be sufficient to focus exclusively on climate-related knowledge and skills, but

that students might also need opportunities to engage in discussions about the potential consequences of climate change.

Climate action in the eyes of young activists – from direct individual to collective indirect actions

Niklas Gericke*, Department of Environmental and Life Sciences, Karlstad University, Sweden
Nina Christenson, Department of Geography, Media and Communication, Karlstad University, Sweden
Carola Garrecht, IPN - Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
Previous research has found that social norms and efficacy are important for self-reported mitigating behaviors in relation to climate change, but less is known about what type of actions more committed students opt for. Therefore, this study aims to describe what aspects of climate action underpin their willingness to act. An interview study with 30 student activists (18-29 years) in Germany and Sweden who are actively involved in climate movements was conducted. The transcribed recordings were analyzed using qualitative thematic content analysis. The proposed actions were coded according the two dimensions of action possibilities: individual/collective and direct/indirect. Two main pathways towards mitigating climate change become visible in the data. The most emphasized pathway describes the importance to create opinion via indirect actions, mainly at the collective level, but also at the individual level, to create pressure on the political system to change legal systems and social norms. A second, less emphasized pathway points to the need for direct individual actions as a way to act as moral role models. The results highlight the needs to redirect climate change education away from only teaching at the individual level, as commonly suggested in climate literacy programs in schools.

Preparing teachers for a warming future – an interdisciplinary approach to address Climate Literacy

Kathryn Leve*, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Ute Harms, IPN - Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
In order to act towards the 1.5°C aim citizens need to be climate literate. To assist young people to develop Climate Literacy is the responsibility of teachers but they themselves are inadequately prepared to do so. Hence, we developed an interdisciplinary approach for teacher education that combines content knowledge and pedagogical content knowledge relevant in the context of Climate Literacy according to experts from science and education. We piloted the program in a digital mode (due to COVID19) consisting of once-a-week-sessions over eight weeks. We evaluated structure, organisation, and teaching of the courses as well as interest and appraisal of taking the topic into classrooms, with both closed and open ended questions. Participants called for a different focus on content knowledge depending on their own subjects and they suggested to produce take home materials for their classrooms. Based on the evaluation results implications for a future design of the program are presented. The program will be rearranged to less but longer intensive teaching phases followed by individual project work in a face to face mode.

Dilemmas in teaching climate change - preservice science teachers beliefs

Mikael Rydin*, Department of Environmental and Life Sciences, Sweden
Niklas Gericke, Department of Environmental and Life Sciences, Sweden
Nina Christenson, Department of Geography, Media and Communication, Sweden
Jesper Haglund, Department of Engineering and Physics, Sweden

ABSTRACT
To combat climate change, it is important to foster young people's climate literacy. Here, teacher education has a crucial task in preparing preservice science teachers to navigate and teach complex and interdisciplinary issues such as climate change. Research has shown that teachers' beliefs influence how they approach teaching climate change. Therefore, the aim of this study is to understand what challenges preservice teachers believe to exist in teaching climate change. Six preservice teachers representing four different school science subjects participated in in-depth semi-structured interviews and the transcripts were analyzed using a thematic coding approach. Findings show two areas of conflict between beliefs. The first area of conflict regards the dilemma of being a neutral and objective teacher in a value-laden context. The second area of conflict regards reaching holistic aims via reductionist means. The findings provide insight into the educational needs for preservice teachers in science teacher education about teaching climate change. We suggest that teacher educators allow preservice teachers to explore and reflect upon their beliefs about teaching climate change, hence enabling them to reconcile areas of conflict between beliefs.

Strand 15: Policy, Reform, and Program Evaluation
SC-Organized Paper Set: Standards and Policy
4/19/23, 8:25-9:55, Astoria (L3)

Testing the Assumption of Equivalence of State Science Standards

Eugene Judson*, Arizona State University, USA

ABSTRACT
The assumption of equivalency was tested among science standards that are based on the same NRC framework as the Next Generation Science Standards (NGSS). Though 20 states adopted NGSS, 24 other states developed their own science standards based on the NRC Framework. The paper begins with explanation of a classification system organizing science standards based on presentations of performance expectations. Following, the study described how nearly 300 elementary teachers were randomly presented three sets of ostensibly similar science standards and prompted to specify what they believed to be the primary student objective and highlight what they noticed most and why. Findings counter the assumption of equivalence among NRC-based science standards and emphasizes ways tools such as typography, typeface, and layout affect teacher noticing.

Concurrent Session 3, 4/19/23, 8:25-9:55

Changing science education standards: How the policy environments changed from NSES to NGSS

Laura Pirkle Howd*, The Pennsylvania State University, USA

ABSTRACT

In the United States, science education has been dramatically re-imagined twice in the last two decades through the introduction of national standards in 1996 (M1) and the overhaul of those standards in 2009 (M2). This project answers questions about how the processes, actors and beneficiaries changed between M1 and M2 and provides a working conceptual framework based on those changes for researchers to be able to better investigate the roles of all of the actors - state and non-state - involved in a particular science education reform. Document analysis of over fifty EdWeek articles and network ethnography techniques are used to construct policy environment maps that show the major actors and directions of policy flows for M1 and M2. Comparison of the maps shows dramatically different processes at work in M1 and M2 and raises questions about power dynamics and beneficiaries from the changes. A new conceptual framework for handling the expanded actors and flows found in the policy environments is described.

Restructuring Middle School Science Education around the Grand Challenges

David Fortus*, Weizmann Institute of Science, Israel
Jeffrey Nordine, University of Iowa, USA

ABSTRACT

Students across the globe are rapidly awakening to the urgency of global challenges, such as climate change, biodiversity loss, global pandemics, fresh water shortages, plastic and air pollution, antibiotic resistance that are shaping their future. Each of these problems involve scientific, technical, economic, and political perspectives; we refer to them as Grand Challenges. We recently organized an invited international mini-conference and discussed theoretical and practical perspectives on radically restructuring science education around the Grand Challenges and students' desire to be well-informed and to develop agency with respect to these issues. The goal of this presentation is to bring the ideas that were raised at this mini-conference to the attention of NARST's membership. The main outcome of the moni-conference was broad agreement that the middle school science standards should be organized according to the Grand Challenges (rather than according to science disciplines), leaving out a great many science ideas currently in the standards (only those that are necessary to make sense of Grand Challenges are kept), and going beyond describing target student competence in explaining phenomena and solving problems to explicitly including affective outcomes such as student interest, motivation, and sense of informed agency.

Funding Patterns of the National Science Foundation's ITEST Program in the Affective Domain: 2002-2022

Gavin Fulmer*, University of Iowa, USA
Asli Sezen-Barrie, National Science Foundation, USA
Jennifer Noll, National Science Foundation, USA

ABSTRACT
We examine the affective outcomes targeted by projects supported by the NSF's Innovative Technology Experiences for Students and Teachers (ITEST) program. Data come from publicly available abstracts for projects awarded by the program from 2002 to 2022, analyzed using a keyword search to compare frequencies and further content analysis of a subset of awards. Results show relatively steady attention to dispositional outcomes such as interest, as well as recent increases in attention to sense-of-self outcomes such as identity or belonging. This reflects changes in focus by the program as well as by the field itself. Interpretations of the content analysis and implications for future research will be discussed.

Concurrent Session 4
4/19/23, 10:20-11:50

Continental and Diasporic Africa in Science Education (CADASE) Sponsored Session: Reflecting on Reform: Movements that Value and Expand the Science Education Experiences of African People and People of African Descent
4/19/23, 10:20-11:50, Grand Ballroom (L2)

Reflecting on Reform: Movements that Value and Expand the Science Education Experiences of African People and People of African Descent

ORGANIZERS
Mary Atwater, University of Georgia, Athens, GA, USA
Rona Robinson-Hill, Ball State University, Muncie, IN, USA
Brenda Brand, Virginia Tech, Blacksburg, VA, USA

PANELISTS
Peter Okebukola, Lagos State University, Nigeria

ABSTRACT
The first part of the 90-minute administrative session sponsored by The Continental and Diasporic Africa in Science Education RIG (CADASE RIG) includes a 45-minute plenary presentation including time for a question and answer period. The invited speaker is Dr. Peter A. Okebukola, Distinguished Professor of Science and Computer Education at Lagos State University. The presentation will be in line with the CADASE theme: Reflections on reform in science education in Africa and the Diasporic environment: Convergencies, Impact and the Future. The second half of the administrative session will include a poster session in which faculty members and doctoral students from U.S. Historically Black institutions, the CADASE RIG, and NARST members will share their work that focus on the RIG"s theme: "Reflecting on Reform: Movements that Value and Expand the Science Education Experiences of African People and People of African Descent". The poster presenters will presided over by Brenda Brand, University of Virginia Tech.

Board of Directors Sponsored Session: International collaborative study of Sustainability and Social Justice in Science Education
4/19/23, 10:20-11:50, Salon A5 (LL)

Concurrent Session 4, 4/19/23, 10:20-11:50

International collaborative study of Sustainability and Social Justice in Science Education

ORGANIZERS
Tali Tal, Technion, Israel Institute of Technology, Haifa, Israel
Gail Richmond, Michigan State University, East Lansing, MI, USA
Joseph Krajcik, Michigan State University, East Lansing, MI, USA
Irene Bayer, Michigan State University, East Lansing, MI, USA
Orit Ben-Zvi Assaraf, Ben Gurion University of the Negev, Israel
Heather Toomey Zimmerman, Pennsylvania State University, PA, USA

PANELISTS
Efrat Nativ Ronen, Technion-Israel Institute of Technology, Israel
Anat Shauly, Technion-Israel Institute of Technology, Israel
Yael Eshed Silver, Technion-Israel Institute of Technology, Israel
Abir Saleh, Technion-Israel Institute of Technology, Israel
Avivit Arvatz, Technion-Israel Institute of Technology, Israel
Odelia Schrire, Technion-Israel Institute of Technology, Israel
Tamar Ginzburg, Technion-Israel Institute of Technology, Israel
Anna Pshenichny Mamo, Technion-Israel Institute of Technology, Israel
Lulu Garah, Technion-Israel Institute of Technology, Israel
Yaron Charka, Technion-Israel Institute of Technology, Israel
Ruth Edri, Technion-Israel Institute of Technology, Israel
Jonathan Bowers, Michigan State University, USA
Maggie Demarse, Michigan State University, USA
Kara Haas, Michigan State University, USA
Kayla Bartz, Michigan State University, USA
Lydia Bradford, Michigan State University, USA
Tatiana Iretskaia, Michigan State University, USA
Jaime Garcia Vila, Michigan State University, USA
Roberta Hunter, Michigan State University, USA
Renee Bayer, Michigan State University, USA
Consuelo Morales, Michigan State University, USA

ABSTRACT
As three NARST past presidents, one of whom is an international member, we understand the importance of exposing graduate students to education systems and their contexts outside their own, and to consider challenges for science education in particular. Due to our universities" initiatives to increase international scholarly collaborations, we designed a joint course for graduate students from the US and from Israel, focusing on ‚ÄúSustainability and Social Justice‚Äù. The course will take place in Israel, in October 2022. Small groups of American and Israeli graduate students will identify a research question during the course. With faculty guidance, they will begin their exploration of this question during the week and continue their investigations in the weeks and months after the course concludes, making use of online platforms to facilitate this work. Among potential data sources will be interviews, field notes

taken during the program, and analysis of historical and scientific documents related to relevant sites and problems being investigated. In our symposium, five to six studies will be presented. Two discussants - an Israeli and an American will discuss the main findings and offer their insights, based on the expertise in sustainability education and social justice.

National Science Teaching Association (NSTA) Sponsored Session: Translating (Y)our Research into Forms that are Useful to K-12 Science Educators
4/19/23, 10:20-11:50, Waldorf (L3)

Translating (Y)our Research into Forms that are Useful to K-12 Science Educators

ORGANIZERS
G. Michael Bowen, Mount Saint Vincent University, Halifax, Nova Scotia, Canada

PANELISTS
Julie Luft, University of Georgia, GA, USA
Valarie Akerson, Indiana University, IN, USA
David Crowther, University of Nevada, Reno, NV, USA
Judith Lederman, Illinois Institute of Technology, IL, USA
Victor Sampson, University of Texas, Austin, TX, USA
Kathy Trundle, Utah State University, UT, USA

ABSTRACT
Panelists will each briefly summarize what research of theirs they translated into an applied perspective accessible to K-12 teachers and what challenges they faced when doing so. The presider will then prompt a panel discussion on what motivated the panelists, why they think making their findings available to practitioners is important, and what venues/approaches they used for doing so. Each panelist will have the opportunity to offer a single piece of advice to attendees who are interested in translating their research for practitioners. Time remaining will be spent addressing questions from the floor.

Strand 1: Science Learning: Development of student understanding SC-Organized Paper Set: Evaluating Information and Transforming Learning in Science Classrooms
4/19/23, 10:20-11:50, Salon C7-8 (LL)

Students' Evaluations of Science (Dis)Information
Daniel Pimentel*, Stanford University, USA

ABSTRACT
Students frequently turn to the internet for information about scientific issues. However, they can find it challenging to evaluate the credibility of the information they find. This study reports on a series of activities designed to teach students to use online reasoning strategies to evaluate science information on the internet. Six ninth grade students participated in 11 activities. They completed pre and post-interviews composed of cognitive think-aloud evaluation tasks. Only one of the six students was able to correctly identify disinformation on the pre-interview task compared to all six of the students on the post-interview task. These results suggest that teaching ideas about the social processes of science along with online reasoning strategies has the potential to help students evaluate scientific information, misinformation, and disinformation encountered on the internet.

Geoscience for justice: a pedagogical model of transformative science learning
Shondricka Burrell*, Morgan State University, USA

ABSTRACT
Students in poor and minoritized communities are more likely to lack access to quality science curricula that combines relevant science content and investigative practices—components the National Research Council (2012) has identified as necessary for effective learning. To address this opportunity gap, I developed and tested the efficacy of a pedagogical model informed by the socio-cognitive constructs of transformative learning (perceived value, relevance, and application of science) and place-based inquiry using a quasi-experimental, within-group and between group comparison design. Results of multivariate analyses were mixed but indicated statistically significant and meaningful positive shifts in knowledge; and perceived value, relevance and application of science thereby supporting the efficacy of the instructional model.

Affordances for Multimodal Representations in a Photosynthesis Unit: Tale of Two Linguistically Diverse Classrooms.
Preetha Menon*, Stanford University, USA

ABSTRACT
A mixed method analysis was conducted to analyze the role of multimodal tasks, visual diagrams, and comic strips, in supporting science learning in two sixth-grade linguistically diverse science classrooms. We address linguistic diversity by using the students' English Learner (EL) status. Using an integrated framework from different perspectives (sociocultural, social semiotic views on multimodality), we describe the affordances of using multiple modes to depict science learning in these tasks, using a science-language rubric, students' notes, surveys, and interviews. Qualitative and quantitative findings were integrated using joint displays. Regression analyses indicate that both multimodal tasks can predict science learning. Redesignated students performed well on both tasks as they integrated the use of all the modes for science learning. Using vocabulary and images for ELs and native English speakers predicted science learning. It was easier for all students to depict their understanding of photosynthesis through visual diagrams, and their descriptions improved over time. The science learning through comic strips was lower for ELs and native English speakers who found the process confusing. This study highlights how multimodal tasks in science can

facilitate the integration between science and language learning but requires scaffolds to support their effective use in the classroom.

Students' Use of Crosscutting Concepts to Develop Questions from an Anchoring Phenomenon

Daniel Voss*, Northwestern University, USA
Brian Reiser*, Northwestern University, Learning Sciences, USA
Joe Kremer, Denver Public Schools, USA
Jamie Noll*, BSCS Science Learning, USA
Dawn Novak, Northwestern University, USA
Michael Novak*, Northwestern University, USA
Nicole Vick, Northwestern University, USA

ABSTRACT
Recent reforms promote three-dimensional science instruction and learning by encouraging students to engage in science and engineering practices using lenses of crosscutting concepts to build understanding of disciplinary core ideas. Crosscutting concepts are the least-studied of these dimensions, but are intended to be leveraged by students from the very beginning of instruction as they are most likely used across different content areas outside of the science classroom. We focus on students' use of crosscutting concepts as they develop questions after experiencing an anchoring phenomenon in a storylines-based unit. We show that students' questions are not only relevant to the unit of instruction, but incorporate components of crosscutting concepts in ways that are unprompted by the materials. Our work operationalizes the crosscutting concepts for application to student questions and provides initial findings that students may intuitively use crosscutting concepts in unexpected ways as they develop questions to examine anchoring phenomena.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Students' Ways of Learning Science
4/19/23, 10:20-11:50, Salon C1-2 (LL)

Preschool-age Children's Use of Spatial Thinking When Making Sense of Astronomical Phenomena

Hannah Lewis*, Wesleyan University, USA
Julia Plummer*, The Pennsylvania State University, USA

ABSTRACT
Previous research has shown that engaging children in spatial thinking predicts future success and participation in science. This study investigates how seven different museum astronomy programs engaged preschool-age children in spatial thinking (N = 60). We used a multi-level qualitative framework to analyze the children's observable behaviors, called spatial sensemaking practices, and then inferred their cognitive processes, called spatial skills. Using those previously established frameworks, we characterized children's use of spatial sensemaking practices and spatial skills. Additionally, we categorized the spatial skills into four

broad groups: Intrinsic-Static, Intrinsic-Dynamic, Extrinsic-Static, and Extrinsic-Dynamic. This yields insight into which spatial skill groups the children engaged with most often. Our results suggest children most often engaged with Extrinsic-Static spatial skills, which involve comparing the properties of multiple static objects. Our second finding describes how all of the spatial sensemaking practices we identified helped facilitate multiple spatial skills, suggesting that the same behaviors can engage children in various cognitive processes. Our third finding describes how each program facilitated spatial skills in only one or two of the four broad spatial skill categories. Overall, this study provides evidence for how museum astronomy programs engage children in distributed spatial sensemaking.

Elementary Children Learn Astronomy Through Drawing
Qingna Jin*, University of Alberta, Canada
Mijung Kim*, University of Alberta, Canada

ABSTRACT
Engaging students in visualization, especially constructing visual representations has been suggested as a fruitful tool to support science learning. This study explored how elementary students learn astronomy, which is a challenging topic for both teaching and learning, through drawing and communicating with others about their drawings. Data were collected from multiple sources and analyzed qualitatively. Findings indicated that drawing as cognitive and epistemic resource facilitated students' reasoning in both individual and social domains.

A Case Study of How Fifth Grade Students Develop Their 21st-Century-Skills during Integrated STEM Unit
Muhammad Purwanto*, University of Minnesota, USA
Gillian Roehrig, University of Minnesota, USA
Elizabeth Stretch, University of Minnesota, USA

ABSTRACT
In elementary schools, calls to develop students' 21st-century skills are becoming more prevalent, as seen through many recent national reports and research. However, there are limited guidelines for defining and assessing students' 21st-century skills and a lack of research related to the assessment of students' 21-st century skills. To assess students' 21st-century skills, we drew on the indicators of 21st-century skills from the Partnership for 21st Century Learning (P21) (2016) and National Education Association (NEA) (2010) and an observational assessment rubric (Sondergeld & Johnson, 2019). This study utilized a single case study to examine how four fifth-grade students developed 21st-century skills during an integrated STEM unit. The participants of this study were four fifth-graders, ages 10-11 years, at a diverse suburban middle school in the Midwest. By analyzing videos and transcripts of small group learning, our finding shows that during an integrated STEM unit, students develop their 21st-century skills based on three broad skills: creativity and innovation (C1), critical thinking and problem solving (C2), and communication and collaboration (C3). From these broad skills, the researchers, then, are able to specify students' 21st-century skills into 25 different indicators of 21st-century skills.

Interest and Effort: Exploring the Ways Students Obtain and Evaluate COVID-19 Information

Eric Kirk*, University of North Carolina at Chapel Hill, USA
Jamie Elsner, University of North Carolina at Chapel Hill, USA
William Romine, Wright State University, USA
Li Ke, University of Nevada, Reno, USA
Laura Zangori, University of Missouri Columbia, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA

ABSTRACT
This proposal outlines the findings of a study designed to further our understanding of how students obtain and evaluate information regarding COVID-19. Between the spring of 2020 and spring of 2021, high school students (n = 243) from the Midwest United States were asked to report their interest in various topics related to the COVID-19 pandemic, the formats and sources from which they obtain information about COVID-19, and the strategies they employ to evaluate the quality of information they encounter. Students were most likely to report being interested in topics with direct relevance to their personal wellbeing such as how to best protect oneself from the virus than topics, whereas more abstract topics such as the structure of the virus were less appealing. Several profiles of how students obtain information were identified, such as groups that primarily obtained information through personal connections, through personal connections, through social media, or through traditional news sources. Level of interest was found to predict the likelihood of devoting effort to seeking and evaluating information. Additionally, there were significant relationships between how students primarily obtained information, and the evaluation strategies they employed.

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

SC-Organized Paper Set: Instructional Approaches and Strategies for Learning Chemistry

4/19/23, 10:20-11:50, PDR 2 (L3)

How Different Approaches to Science Teaching Affect Content Knowledge-Linking Concerning the Energy Concept

Dennis Dietz*, Freie Universität Berlin, Germany
Claus Bolte, Freie Universität Berlin, Germany

ABSTRACT
In contrast to English-speaking countries (like the US), science at the secondary level in Germany is taught differentiated into biology, chemistry, and physics. According to learning theories, many researchers assume a superiority of the integrated science teaching approach concerning knowledge-linking – although empirical evidence is still scarce. In this study, we investigate the effects of both science teaching approaches on students' content knowledge-linking performance within the energy concept. The choice of the topic energy appears reasonable to us, since energy is a cross-cutting concept which is important in all science

subjects. To investigate long-time effects, we examine essays from students at a German academic high school who received either subject-differentiated or integrated science instruction in grades 7 and 8. By developing our own theory-based model, we can analyze students' content knowledge-linking performance in essays regarding three dimensions: intra-subject linkage level, inter-subject linkage and scientific correctness. Our analysis shows that students receiving the integrated science approach (N(tg1) = 141 and N(tg2) = 137) show significantly more frequent as well as superior content knowledge-linking than students receiving the differentiated science approach (N(cg) = 132). In addition, these students are more often able to link subject-specific terms in a cross-curricular way.

Teaching High School Students about Brønsted-Lowry Acid-Base Reactions

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Anja Lembens, University of Vienna, Austria

ABSTRACT

Acid-base reactions play a vital role both in the chemistry classroom and in our everyday lives. However, teaching about the subject is not a trivial matter, especially when it comes to a general trade-off in institutionalized teaching, i.e., the tension between fostering students' learning processes and assessing their learning gains. This intervention study evaluates a learning environment about Brønsted-Lowry acid-base reactions for high school addressing these issues (N=85). To assess the participants' learning gains, a knowledge test was developed and piloted with a group of students (N=134). The tasks showed satisfying properties with respect to the item response theory paradigm, and, subsequently, were distributed to students of our target group before and after the intervention. The results show a significant growth in knowledge over the course of the intervention, thus implying a fit of student-focused lesson plans and criteria-based assessment. In the presentation, we discuss how such a fit can systematically be implemented in similar learning environments, and to what extent we interpret learning and assessing in chemistry education as two sides of the same coin.

Exploring high school students' systems thinking and explanation of chromatography through analogy

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ABSTRACT

Promoting students' scientific literacy through scientific inquiry has been applied to many fields of science education. Existing literature reveal that students' systems thinking ability is supportive to their performance in science inquiry. However, the difference between students' systems thinking ability and explaining chemistry phenomena are understudied. A mixed method of quantitative and qualitative research was used in this study. A total of 118 11th grade students from southern Taiwan participated in the scientific inquiry course of thin layer chromatography for 10 weeks. Initial results showed that students with higher systems thinking

ability outperform their counterparts of low level systems thinking on chemistry explanation levels. High school students were capable of using the theoretical descriptive level when an appropriated scaffolding was provided. Moreover, those analogies with the theoretical explanatory level by the high systems thinking ability students presented the complete interaction of molecules and correct chemistry concept. These initial findings suggest that systems thinking plays a significant role in advancing student scientific competency of explaining phenomena scientifically.

The Wonders of CTCA in Making Learning of Science Easy: A study of Nuclear Chemistry

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Deborah Agbanimu, Lagos State University, Africa Centre of Excellence for Innovative and Transformative STEM Education, Nigeria
Esther Peter, Lagos State University, Africa Centre of Excellence for Innovative and Transformative STEM Education, Nigeria
David Byamungu, University of Burundi, Burundi
Chinyere Ikpah, Lagos State University, Africa Centre of Excellence for Innovative and Transformative STEM Education, Nigeria

ABSTRACT

The focus of this study was to find out if there: (i) will be a statistically significant difference in retention of chemistry students taught nuclear chemistry using CTCA and lecture method; (ii) is any statistically significant difference in male and female students taught nuclear chemistry using CTCA. The study was built on Vygotsky's constructivism theory, Ausubel's subsumption theory of meaningful learning, and CTCA's philosophical framework. Explanatory sequential mixed methods research approach was employed and quasi-experimental research design was adopted. The sample size was 128 senior secondary II (equivalent to 11th grade) students from two senior secondary schools selected using the convenience sampling technique. Nuclear chemistry achievement test (NCAT) with a reliability coefficient value of 0.80 was administered as pretest, posttest, and retention test to both groups. Statistically significant difference was found in method of teaching [$F(1, 125) = 357.71$; $p = 0.00$] which was in favour of the CTCA group [mean = 24.01] compare to the lecture group [mean = 10.29]. There was no statistically significant difference in retention of male and female students taught nuclear chemistry using CTCA [$F(1, 66) = 0.06$; $p = 0.81$]. Male [mean = 23.93] and female [mean = 24.07].

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Graduate Student Professional Development
4/19/23, 10:20-11:50, Blvd A (L2)

Learning and Leading: Doctoral Students' Perceptions of Imposterism and Academic Challenges in an Interdisciplinary Program

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Julianna Nieuwsma, NC State University, USA
Rebecca Ward, NC State University, USA
Kathleen Bordewieck, NC State University, USA
Emma Refvem, NC State University, USA

ABSTRACT
Graduate students are increasingly reporting experiencing emotional stress and feelings of imposterism in their graduate education. This exploratory study investigated STEM doctoral students' reported emotions and self-efficacy in conducting different aspects of STEM research. Results showed that students felt most confident in collecting data, collaborating with others, and presenting research and least confident in writing grant proposals, writing articles, and preparing human ethics applications. When experiencing academic challenges, students most often reported feeling anxiety, frustration, and defeat. Differences in perceptions were found when data were analyzed by imposter phenomenon scores and those students with high reported imposterism, were likely to report negative emotions and those with low imposterism were more likely to report optimism. There was also evidence that some students experienced shifting academic self-concept related to being in an interdisciplinary program.

Supports and Challenges in the Phases of Doctoral Education: Physical Science Doctoral Student Perspectives

Anne McAlister*, University at Buffalo, USA
Sarah Lilly*, University of Virginia, USA

ABSTRACT
Doctoral education is described as a progression through different stages. Few studies examine the identity development of doctoral students progressing through these stages, particularly from students' perspectives. The purpose of this exploratory, multiple case study is to examine physical science doctoral students' experience of the supports and challenges that they reported encountering as they pass through the phases of graduate school. We address the research question: What supports and challenges do doctoral students report that they experience in each phase of their graduate education? We used narrative-style interviews to explore the graduate school experiences of eight physical science doctoral students and constructed a descriptive memo for each interview to highlight salient themes. Participants identified the challenges of facing rejection, balancing multiple roles, receiving mixed messages about how to spend time, shrinking community support, and feeling like they would not impact society through their field of physical science. Further, our results expand upon

current models of doctoral student identity development by demonstrating an additional phase of graduate school as participants conceptualized graduation and choosing a career as distinct from the time that they focused on their dissertation. This study includes implications towards improved support for, and increased persistence of, doctoral students.

Graduate Students' Interpersonal Communication Skills: Assessing an Online Course

Yehudit Judy Dori*, Technion, Israel
Shahaf Rocker Yoel, Technion, Israel

ABSTRACT

This study examines the effect of a graduate course titled "Selected topics in interpersonal communication skills" on its students' interpersonal communication skills as part of their 21st century skills. Subject to the COVID-19 constraints, the course consisted of synchronous lectures and practice sessions. The 46 graduate students were from various science, technology, engineering, or mathematics (STEM) domains at a research university. The research aimed to find whether the interpersonal communication skills of the participants change following the course, and if so, in what ways. Research tools included students' presentations, questionnaires, peer-feedback, and self-reflections during the course. Analyzing the data both quantitatively and qualitatively, we found that the graduate students improved their written and oral interpersonal communication skills and benefited from exposure to a variety of knowledge and research fields, contributing to a sense of pride in their university affiliation. The students suggested adding a practical component on providing constructive feedback and rendering the course mandatory to all the graduate students in the university. The contribution of this research is the design of an assessment method of an online course that develops interpersonal communication skills among graduate students from a variety of STEM domains.

Teaching Assistant Talk Move Sequences Associated with Rigorous Elicitation Discussions in an Undergraduate Biology Laboratory

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Ron Gray, Northern Arizona University, USA
Anna Grinath*, Idaho State University, USA

ABSTRACT

Eliciting student thinking as resources for learning is central to productive sense making. Educators use pedagogical tools such as talk moves to direct classroom conversations toward and sometimes away from student learning. This qualitative case study describes how teaching assistants (TAs) use talk moves to elicit and work with student ideas in an undergraduate general biology laboratory course. We used conversation analysis to examine turn by turn interactions and identify and describe sequencing of talk turns that elicited explanatory rigor. We used criterion sampling to examine 18 episodes of the same planned elicitation discussion that took place during the beginning of the lab investigation. The 18 episodes were collected from 6 different TAs who enacted the planned discussion across three semesters. The goals of the discussion and the central puzzling phenomenon were the same across the 18 episodes. This study contributes a description of talk move sequences and three other factors that

provide insight to features of rigorous elicitation discussions. These contributions have implications for future research to test hypotheses based on the qualitative findings and for informing TA professional development focused on elicitation discussions. Additionally, the exemplars can be used to illustrate how talk moves function as pedagogical tools.

Strand 7: Pre-service Science Teacher Education
Related Paper Set: Using Principles of Engineering Design to Advance Elementary Science Teacher Preparation
4/19/23, 10:20-11:50, Salon A1 (LL)

Integrating Learning of Science with Engineering Design in a Physics Course for Elementary Preservice Teachers

N. Sanjay Rebello*, Purdue University, USA
Zeynep Akdemir, Purdue University, USA

ABSTRACT
The Next Generation Science Standards (NGSS) emphasize the learning of Science and Engineering Practices (SEPs). We investigated the extent to which pre-service elementary teachers enrolled in a conceptual physics course for elementary educators demonstrated evidence of performance surrounding the key science and engineering practice of analyzing and interpreting data as they participated in in an engineering design-based science experience related to simple circuits. Data analysis involved coding the pre-service teachers' artifacts for their capacity to engage in analyzing and interpreting data. We developed and validated a rubric with multiple levels of performance. Our results showed that over three-quarters of the student groups demonstrated evidence of analyzing accurately the data in the context of an engineering design experience. Approximately one-third of the groups were able to interpret the data in light of their design criteria.

The Impact of Engineering Design on Elementary Preservice Teachers' Achievement in Science

Selcen Guzey*, Purdue University, USA

ABSTRACT
This study focuses on the impact of the engineering design activities developed by university instructors teaching content courses on undergraduate elementary education students' learning of science concepts. Instructors administered an online pre- and post-content assessments to assess student knowledge and retention of science concepts in the chemistry, biology, and physics courses. Data collection was occurred between 2017-2021. We detected significant learning gains in all but one of the courses assessed (Chem-2017). Results show that engineering design-based curricula can support undergraduate students' development of content knowledge and retention.

Concurrent Session 4, 4/19/23, 10:20-11:50

Measuring Elementary Preservice Teachers' Conceptualizations of Engineering and Perceived Abilities to Teach Science Using Design

Yue Li*, Miami University, USA
Brenda Capobianco, Purdue University, USA

ABSTRACT

This paper outlines the development, implementation, validity, and reliability of a survey instrument designed to measure elementary preservice teachers' (PST) perceptions of engineering design and their perceived abilities to teach science using engineering design as they progress through a series of engineering design-based learning experiences in an elementary science teacher preparation program. Through four survey development and modification phases, the researchers used expert review, exploratory factor analysis, confirmatory factor analysis, and internal consistency reliability approaches to assess survey validity and reliability properties. The final instrument consists of 21 5-point rating scale items measuring PSTs' conceptions of engineering design practices and 21 parallel items measuring PSTs' preparedness to teach science using engineering design. Results from the development and implementation of this instrument highlight the multi-functional and flexible utility of this measure to not only characterize how preservice teachers are learning about engineering design but also to determine if and how project objectives were being met (evaluation purposes) and how evidence from the tool informs and transforms the development and implementation of the course-based design tasks (instructional purposes).

Elementary Preservice Teachers' Shifts as Learners to Teachers to Designers

Brenda Capobianco*, Purdue University, USA
Jenna Gist, Purdue University, USA

ABSTRACT

In this study, we employed the use of engineering design thinking as a responsive means of positioning our PSTs as designers of their own teaching and learning. While considered a distinguishing activity in engineering, design thinking has gained momentum in the discipline of education whereby solving problems demands the ability to assess the conditions of a given situation and adjust one's actions depending on a current set of needs. For PSTs this means evaluating their own classroom situation and monitoring and adjusting their instructional and curricular decisions based on the needs of their students. Hence, we seek to learn how PSTs plan for, enact, and reflect on their lived experiences as designers of their own formative practice. Data were collected via interviews, classroom observations, lesson plans, and reflective narratives. Data analysis entailed open coding and document analysis. Results indicated that PSTs demonstrated a progressive shift as learners and teachers to designers. When reflecting on their overall experience, PSTs characterized design as an integrator and transformer, suggesting a significant shift in their personal learning and application of design.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Communities of Practice: Sites for Teacher Learning
4/19/23, 10:20-11:50, Salon C5-6 (LL)

Communities of Practice to Enhance Preschool Teachers' Science Ways of Seeing and Identity

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Veena Vasudevan, University of Pittsburgh School of Education, USA
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ABSTRACT
Science in early childhood sets a foundation for scientific understanding, and contributes to the development of important skills, attitudes, and critical thinking processes necessary for learning and interacting with the world, yet, access to high quality science learning for young children is limited (Sackes, 2014; National Academies of Sciences, Engineering, and Medicine, 2022). Teachers, as the primary curators of learning in preschool settings, greatly affect young children's access to science learning. Teachers' knowledge of, experience with, and attitude towards science determines how science is taught (Sackes, 2014). In this study, we explore how preschool teachers' participation in a community of practice (CoP) (Lave and Wenger, 1991) focused on science teaching shaped: 1) the way they participated; 2) the way they see the world; and 3) the way in which they see themself in the world. As preschool teachers participated in their science learning CoP, and engaged in scientific activities, they began to perceive themselves as people who could do science. Overall, participation in a CoP inclusive of educators from a museums provided early childhood teachers the opportunity to sit alongside science professionals in science-rich learning environments and, together, re-envision the opportunities for young children to learn science.

Responding to High School Physics Teachers' Needs in a Professional Community of Practice

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Tim Stelzer, University of Illinois at Urbana Champaign, USA

ABSTRACT
Providing high-quality professional development for teachers with diverse backgrounds and expertise is a challenging task. In this work, we investigated a partnership program which has been designed to be responsive to high school physics teachers' needs to provide a more effective community of practice. This program aims to address disparities in physics instruction by equipping teachers with university physics curricula and equipment adapted to fit the context of their high school classrooms. Using interviews and surveys from 14 physics teachers, we studied the extent to which the program has responded to teachers' diverse needs while supporting their participation in a professional community of practice. The results revealed responsive professional developments – conceptualized as being attentive to teachers' needs- have created multifaceted ways of support and collaboration beyond the dynamics of the communities of practice framework. In addition, teachers' perceptions of the effectiveness of the program were positive and very much aligned with the high-quality PD elements that we plugged into the program to create a vibrant community of practice.

Concurrent Session 4, 4/19/23, 10:20-11:50

Identifying Valued Outcomes of Science Teacher Leaders' Participation in Communities of Practice

Michelle Phillips*, Exploratorium, USA
Sara Heredia, University of North Carolina Greensboro, USA

ABSTRACT
In the decade since the development of the NGSS, science teacher leadership (STL) has been an important mechanism for supporting the standards' implementation. The variation in how science teacher leadership is developed and enacted in practice suggests the need for professional learning support that can be flexible to this variation. This study examined an STL community of practice (CoP) as a responsive model of professional support, and applied a value creation framework to better understand the outcomes of the CoP through cycles of learning designed to support the boundary spanning work of science teacher leaders. We identified features of the CoP design that supported boundary spanning, including focus on a common issue, coming to consensus about defining that issue, and dedicated time with other STLs to locate, interpret, and modify resources that align to that shared understanding to use in their contexts. The findings have implications for how to support science teacher leaders as they work to understand and promote antiracist and culturally responsive science teaching while supporting implementation of NGSS. We also provide evidence for how a value creation framework is useful for intentional designing of STL professional learning opportunities to promote NGSS-aligned equitable science instruction.

It's the First Time it's Authentic: Developing Rightful Presence within a Critical Community of Practice

Desiré Whitmore, Exploratorium, USA
Ti'Era Worsley*, The University of North Carolina at Greensboro, USA
Rita Barrera, Stockton Unified School District, USA
Eric Cross, San Diego Unified, USA
Melody Ewey, Davis Joint Unified School District, USA
Camille Fowler, San Diego Unified, USA
Amy Kraft, Sacramento County Office of Education, USA
Tara Sikorski, Santa Clara County Office of Education, USA
Sara Heredia, The University of North Carolina at Greensboro, USA

ABSTRACT
Issues of systemic racism have long been documented within STEM and STEM education. Furthermore, white women make up the majority of science teachers and have likely had little to no opportunities to discuss or engage with issues related to race and racism in science, especially in their teacher education programs. This proposal looks at how a community of practice (CoP) supported science teacher leaders (STLs) to reframe values while becoming racially-just science teachers. To frame our work we use rightful presence as a means to identify the value outcomes of the CoP. Design-based research methods and critical ethnographical tools are used to understand the participation and impact within the design space. Through interaction analysis we unpack how rightful presence emerged in the CoP. Three themes were identified as key to establishing rightful presence that include; humanizing

of STLs, sharing of lived experiences through multiple perspectives, and creating space for critical conversations. Together these themes highlight the importance of relational development within STL networks when discussing and enacting racially-just science practices.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Science Teacher Learning through Professional Development Opportunities: Planning for and Reflecting on What Teachers Learned
4/19/23, 10:20-11:50, Blvd C (L2)

The design of science teacher professional development intervention through linkage of science teacher learning needs

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Dace Namsone, University of Latvia, Latvia

ABSTRACT
In many areas of education, there have been debates about the meaning, importance, utility, and methods of learning needs and their assessment. Only few research have focused on teacher learning needs in the context of science teacher professional development. This research is an attempt to conceptualize science teacher learning needs (STLN) regarded to differentiation in science classroom and to use the identified STLN in the design of a science teacher professional development intervention. A conceptual framework consisting of three categories and two criteria was developed to conceptualize STLN. The data about teacher groups STLN was used to choose contents for the professional development intervention regarded to differentiation in science classroom and strategies how to support science teacher learning throughout the intervention. The results indicate that science teachers are scattered in their STLN and that a wide variety of strategies that support science teacher learning are demanded to respond to the identified STLN.

Insight Into How Professionals Develop: Examining Teachers' Reflection and Sensemaking During Professional Development

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Miray Tekkumru-Kisa, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT
Reflection allows teachers to evaluate their past instruction and make decisions to guide their future practice (i.e., Killion & Todnem, 1991; Moore-Russo & Wilsey, 2014). The literature on teacher sensemaking suggests that engaging in reflection might support sensemaking about changes to teachers' practice (e.g., Marco-Bujosa et al., 2017; Senzen-Barrie et al., 2020). However, prior research has not connected teachers' engagement in reflection to their sensemaking. By using video data of PD, we analyzed the category of reflection (Moore-Russo & Wilsey, 2014) teachers participated in, the process of sensemaking (Robertson & Richards,

2017), as well as what teachers were sensemaking about in relation to the PD's design. Our analysis indicated that teachers typically reflected by sharing their individual viewpoints and used the process of negotiation to consider how to facilitate productive talk. Additionally, different features designed as a part of the PD (i.e., general discussion, redesign, video) supported teachers to participate in different types of reflection and processes of sensemaking. The findings from this study have implications for teacher PD design features and their role in facilitating reflection and promoting sensemaking.

Science teachers' conceptualization of student resources during and after involvement in curriculum-based professional development

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Samuel Lee*, Boston College, USA
Katherine McNeill*, Boston College, USA
Caitlin Fine*, Metropolitan State University of Denver, USA

ABSTRACT
Students enter science classrooms bringing with them dynamic resources that influence their thinking. Student resources (SR) are ways of speaking, knowing, acting and valuing that students use to make sense of the world (NRC, 2015). Students develop these resources as they live their daily lives within their families and communities (Bell et al., 2019). Researchers have found teachers benefit from support to make space for and notice students' science ideas to further sensemaking (Haverly et al., 2020). Professional development (PD) is one way to support teachers to create more equitable learning spaces in their science classrooms. We addressed the research questions: 1) How do teachers conceptualize student resources during and after involvement in curriculum-based PD? 2) How did the design of the PD influence how teacher's conceptualize student resources? We qualitatively describe how teachers conceptualize SR during and after a PD session using video footage and interviews based on their alignment to the definition of SR. Findings suggest that there may be a terminology issue with the term SR and that designers may need to work on how to have teachers iteratively define the term before using it to notice and leverage what students bring to the science classroom.

What Constitutes Program Success? An exploration of findings 2.5 years after a Teacher Professional Development

Joanna Philippoff*, University of Hawaii at Manoa, USA

ABSTRACT
Many studies have looked at changes in teacher knowledge, beliefs, and behavior over the course of professional development programs, but long-term follow-ups are rare. In this study the same instruments were administered to the same teachers (N = 23) before and after a professional development intervention and 2.5 years later. The teachers were also interviewed about factors that enhanced or impeded implementation. The teachers demonstrated pre- to post-gains on instruments examining inquiry-based teaching knowledge, content knowledge (marine science), and self-efficacy. Although scores on these instruments dropped significantly

2.5 year later, they were significantly higher than baseline levels. On a pedagogical content knowledge instrument the teachers' scores did not grow significantly pre- to post-intervention but grew significantly from the post-professional development to the follow-up time point. Interviews revealed self-reported gains in confidence, inquiry and content knowledge, and modest to substantial changes in teaching practice attributed to the intervention. While explicit use of pedagogy and activities declined over time, aspects of the intervention pedagogical approaches became embedded in teachers' practices. This case study emphasizes the need for long-term support of teachers to sustain change over time and has implications for interpreting the outcomes of professional development.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set: Transforming curriculum and assessment for teacher professional development
4/19/23, 10:20-11:50, Salon C3-4 (LL)

Towards assessment for playful learning in early childhood: Influences on teachers' science assessment practices

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Jan van Driel, The University of Melbourne, Australia
Caroline Cohrssen, University of New England, Australia

ABSTRACT
Assessment for learning equips teachers to make purposeful decisions for science teaching and learning. Consistent evidence from Australian national quality standards has identified a need to strengthen teacher capabilities in assessment. This research investigated teachers' assessment practices, and the influences on these practices, during the implementation of a suite of playful science experiences in long day care and preschool settings in the Northern Territory (NT), Australia. Teachers were introduced to the NT Preschool Science Games and supported to apply an assessment tool designed for the observation and development of science process skills. Adopting a multiple case study approach, semi-structured interviews from three cases were thematically analyzed. Findings demonstrate that despite having specific tools to support assessment for learning, these were inconsistently applied. Thematic analysis of semi-structured interviews revealed that assessment practice was influenced by contextual influences, affective responses, and teaching practice. Unpacking these themes further, we identified that following children's interests was associated with the absence of systematic assessment of scientific thinking to inform planning for learning within the informal curriculum. To support teacher practice in early childhood science and promote the assessment of children's capabilities within playful learning, we propose a model of Assessment for Playful Learning.

Educative Curriculum Materials for Science Teacher Educators: Uptake of Different Types of Educative Supports

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Josie Melton*, Western Washington University, USA

Dustin Van Orman*, Western Washington University, USA

ABSTRACT
Curriculum materials have been long suggested as a means of supporting teacher learning but little attention has been given to the development of curriculum materials for educating teacher educators.We used a theoretically and empirically grounded process to develop a set of educative curriculum materials (ECM) designed to promote the development of content knowledge for teaching (CKT) about matter in elementary science teacher education. In this study, we examine how different types of educative features in the materials were used, interpreted, and incorporated into instruction by eight science teacher educators. Our study contributes new insight into the ways different types of educative features play different functions in supporting science teacher educators' pedagogical design capacity during planning, enactment, and customization of ECM.

High School Science Resources on Teachers Pay Teachers: Buyers and Sellers
Adepeju Prince*, Kent State University, USA
Shannon Navy*, Kent State University, USA

ABSTRACT
Teachers use online resources to supplement their curriculum. However, little is known about the sellers of online science resources and how teachers consider seller characteristics when searching for resources. This paper focuses on the characteristics of sellers of science resources on the online site Teachers Pay Teachers (TpT), the products that high school science teachers purchase from the sellers, and if these science teachers consider seller quality. The participants were high school science teachers in the United States. Findings revealed that most of the sellers had information in their TpT profiles that matched the science subjects and grade level of their listed resources. However, some resources were listed across the K-12 grade levels with little information on how to differentiate for the different grades. In addition, the teachers rarely considered the content or teaching background of the seller. The study highlights the importance of ensuring that the sellers of these resources are qualified, and this is reported accurately on their profiles. In addition, teacher-buyers should also consider the credibility and quality of the sellers from whom they purchase science teaching resources.

Grading and Retention in CS Service Courses: A Systematic Review
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Saira Anwar, Texas A&M University, USA
Tracy Hammond, Texas A&M University, USA

ABSTRACT
Computer science education has considered many improvements; prior research has emphasized the importance of grading and assessment in CS courses. To understand the current state of literature about competency-based grading in computer science courses, we used the systematic literature review approach. Further, we set out to examine first-year students' correlation in retention in their chosen STEM major once we use competency-based

grading in their courses. This systematic review answers three research questions: RQ1) What are the current methods used in competency-based grading in CS and STEM classes? RQ2) Which methods lead to higher levels of retention? And, RQ3) What correlations exist in retention and competency-based grading classroom? We collected the research studies published between 2005 – 2022 from four databases namely ERIC, PsycInfo, Compendex, and ACM. We applied inclusion and exclusion criteria on 304 studies and included 19 studies in the synthesis. We analyzed the data using qualitative content analysis and identified emergent themes. The paper will answer the research questions according to the literature review and look at the correlation between curriculum design and retention. In conclusion, the paper highlights the current research in competency-based grading and provides the gaps for future research.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Inclusion in STEM Higher Education: (Re)evaluating Pedagogies, Programs, and Research Instruments
4/19/23, 10:20-11:50, Salon A2 (LL)

Gender Differences in a Physics Research Experience for Undergraduates Program

Andrea Ratcliff*, University of Kentucky, USA
Tracy Gastineau-Stevens*, University of Kentucky, USA
Cameron Richards, University of Kentucky, USA
Jennifer Wilhelm, University of Kentucky, USA

ABSTRACT
Research Experiences for undergraduates (REUs) have emerged as co-curricular activities that aid in student learning and achievement. Although most students who participate in REUs benefit from the experience, but more so with women and underrepresented minorities (URMS). In this research proposal, a two-year physics and astronomy REU program was researched and evaluated. The perceptions of students and faculty mentors were found to show an overall positive experience for both summers with some logistical areas that can be improved. In year two the study evaluated potential gender differences as well as motivational perspectives of all students more in depth. Preliminary findings indicate significantly higher scores for females in two areas: 1)The REU experience's impact on their research efforts and 2) perceptions about research careers. Overall, the REU was deemed successful by the undergraduate students and faculty with minor issues needing to be addressed in future years.

Investigating Motivational Supports for Graduate Students through Structural Equation Modeling

Karen Collier*, North Carolina State University, USA
Margaret Blanchard*, North Carolina State University, USA

ABSTRACT
The Graduate Student Support Survey was used to identify factors that support and inhibit the success of graduate students. The survey was developed with a desire to illuminate differences between graduate students from different backgrounds, especially underrepresented populations in science, technology, engineering, and mathematics (STEM). Self-determination theory identifies three basic psychological needs for inherent and intrinsic motivation: autonomy, competence, and relatedness. These constructs were used to develop a structural equation model of whether exogenous variables (i.e., microaffirmations, microaggressions, financial support, and mentor relationships) acted as extrinsic motivators that could thwart or support these basic psychological needs. These were measured with items measuring perceptions of imposter syndrome, sense of belonging, and access and opportunities. Students who perceived more microaffirmations, mentor relationships, and financial support had a greater sense of belonging. Those who perceived more microaggressions experienced more imposter syndrome. Female and nonbinary individuals encountered more barriers with financial support and microaggressions, while master's and part-time students had fewer opportunities for research, publishing, and mentor relationships. Additional findings and recommendations will be discussed.

I am (sort of) a STEM person: College STEM students' self-assessment of STEM identities
Heidi Cian*, Florida International University, USA
Remy Dou, Florida International University, USA

ABSTRACT
STEM (science, technology, engineering, and mathematics) identity, or sense of oneself as a STEM person, has captured the interest of STEM educators and researchers due largely to its relationship with STEM career pursuit or attainment. However, this focus on STEM career outcomes suggests that STEM identity survey instruments may be ill-suited to differentiate between how STEM-affiliated individuals (e.g., college students) see themselves in STEM. Further, the ability for these instruments to detect marginalizing thinking about STEM personhood has not been examined in this population. In this mixed methods study, we explore the extent to which college STEM students attending a Hispanic Serving Institution who rate themselves highly in STEM identity on a survey discuss their sense of themselves as STEM people in interviews. We find that students talk about their STEM identity in ways that minimize their STEM personhood, particularly by considering intelligence and knowledge as the ultimate identifier of a STEM person and comparing themselves to an ideal who embodies white masculinity. This work implies a need to rethink STEM identity survey instruments to better capture marginalizing perspectives of STEM participation and to consider the potential of these instruments to perpetuate, rather than detect, such perspectives.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Supporting Multilingual and Refugee Learners through Translanguaging and Culturally Sustaining Pedagogies
4/19/23, 10:20-11:50, Salon A3 (LL)

Shifting between languages during inquiry process

Lulu Garah*, Technion - Israel Institute of Technology, Israel
Shulamit Kapon, Technion - Israel Institute of Technology, Israel

ABSTRACT
We present findings from an ethnographic case study that documented the participation of two 11th grade language-minority female high achieving students (Arab citizens of Israel) in an authentic physics inquiry. The students' first language is Arabic, but they are fluent in Hebrew. Their mentor was a Jewish kibbutz physics teacher whose first language is Hebrew and who speaks very little Arabic. The inquiry took place in a regional kibbutz high school that significantly differs from the students' Arab school (language, norms, culture, and available resources). Data were collected through videotaped participant observations of authentic working sessions over two years and interviews with the students and the mentor. Using social linguistics discourse analysis of selected episodes, we examine how students' moves between languages (i.e., code-switching between Hebrew and Arabic) shaped and facilitated the nature of their engagement in the inquiry. We illustrate how students' code-switching was utilized to (1) better express their line of thought and reasoning; and (2) to create a private space for reasoning and sense-making from which the mentor was deliberately excluded. Thus, researchers should be wary of automatically interpreting code-switching as simply indicating a lack of proficiency in the majority language, since it may indicate deeper challenges.

The Role of Language in Understanding Abstract Chemical Concepts in Multilingual Classrooms

Salwa Ali*, American University of Beirut, Lebanon
Saouma BouJaoude*, American University of Beirut, Lebanon

ABSTRACT
Based on the sociocultural perspective, an approach to overcome second language learners' challenges in learning science is to embed learning in authentic scientific practices utilizing students' everyday meaning-making and language, particularly home language. In this respect, this study investigated the language practices teachers use to support conceptual understanding in secondary chemistry classrooms and explored how the use of home language (spoken Arabic) facilitated students' understanding in secondary chemistry classrooms. Data came from two secondary chemistry classrooms of different contexts in MECountry. Each classroom was observed and videotaped for six sessions and teachers were engaged in informal conversations about the language of instruction concerning science and learning. Language practices and participants' meaning making were analyzed by using a multi-level dialogic framework. Classroom discourse was analyzed based on communicative approaches (authoritative/dialogic), patterns of discourse, and emerging science knowledge types and cognitive processes in addition to the languages deployed. The findings indicate that teachers used home language for various purposes within the classroom (e.g. affective, linking concepts). Higher levels of knowledge types and cognitive processes often involved the use of the home language. Based on the study findings, the use of the home language promoted more meaningful learning of the science concepts.

Insights on culturally sustaining science pedagogy in an after school program for refugee youth.
Bolaji Bamidele*, Utah State University, USA
Sarah Braden, Utah State University, USA
Tino Nyawelo, University of Utah, USA
Sherry Marx, Utah State University, USA
Aryn Dotterer, Utah State University, USA
Raquel Goldrup, Utah State University, USA
Melanie Valera, Utah State University, USA
Ricardo Gonzalez Montalvo, University of Utah, USA

ABSTRACT
The U.S. education system presents challenges for refugee-background youth from minoritized racial backgrounds. Cultural differences between home and school, socioeconomic challenges, and socio-emotional challenges persist for refugee-background youth in K-12 classrooms. What is even more challenging is navigating through the socio-political and structural barriers affiliated with their refugee identities. Naturalistic conversations, interviews, and field notes were used to collect data from a diverse group of refugee middle and high school students in a two-year critical ethnography study embedded in a physics afterschool program. Using the critical race theory and Garfinkel's ethnomethodology, the study revealed youth disinterest in science at school and positive acknowledgments of doing science in a non-formal environment. Students found the formal schooling environment challenging and consider some of their teachers and peers overtly reiterating their racial difference, which further reduces their efficacy in science-related courses. This study is significant in unpacking the salient contribution of science instructors to students' efficacy and science identity from an equity-oriented perspective. Lastly, the study attests that informal learning environments, serve as an affinity space for ostracized students as they destress from the political terrain of schooling and enjoy being the racial majority in a science learning environment.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set: Issues & Trends in NOS Research
4/19/23, 10:20-11:50, Astoria (L3)

Review of the Research on Teaching, Learning, and Assessment of Nature of Science: 2013–2021
Fouad Abd-El-Khalick*, University of North Carolina at Chapel Hill, USA
Norman Lederman, Illinois Institute of Technology, USA

ABSTRACT
This paper provides a systematic review of research on the teaching, learning, and assessment of nature of science (NOS) in science education since the publication of Volume II of the Handbook of Research on Science Education; the nine-year period from 2013 to 2021. A total of 132 empirical studies published in rigorous, peer-refereed journals were reviewed, revealing several shifts within and beyond established patterns and threads of NOS research. First,

interventions aimed at improving NOS understandings among teachers and students represented the leading category. Past arguments about how best to teach NOS have all but subsided. Instructional interventions were realized in an admirable array of diverse, innovative, and multifaceted instructional sequences, pedagogies, and contexts. Also, interventions mostly counted in weeks and months compared to the short-lived ones that were common in the field. Second, NOS assessment has stabilized into a continuation of current framework and instrumentation patterns with very few systematic efforts to develop new assessment approaches or instruments. Third, a decidedly growing category of NOS research included examinations of the manner, accuracy, and/or extent of NOS representations in national science education frameworks, curricula, and/or standards, as well as in commercial science textbooks and other instructional resources.

A Systematic Review of NOS Research in Science Education: Varieties of Scholarship, Trends and Considerations

Noushin Nouri*, University of Texas Rio Grade Valley, USA
William McComas*, University of Arkansas, USA
Maryam Saberi, Ministry of education, Iran, Islamic Republic of

ABSTRACT
From the time Nature of Science (NOS) was introduced as a vital school subject, much has been published on this topic. The aim of this project is to look over the past 25 years in six key science education research journals and consider what trends might be seen with respect to studies of NOS. A systematic literature review (SLR) and further qualitative content analysis were used for finding and analyzing the articles that featured NOS. This article provides a proposed typology of the research agendas in science education with respect to NOS. Eleven categories have emerged including: Teaching NOS to students, Teaching NOS to teachers, Teachers' NOS classroom practices and knowledge transfer, NOS assessment development and application, Analyzes of textbooks and science curricula, Relationships between NOS knowledge and other variables, Scientists and science educators' views of NOS, Development of NOS instructional materials and frameworks, Cultural considerations in NOS research, Non-empirical commentaries on NOS and NOS Instruction, and a heterogeneous miscellaneous category. Interesting trends are reported and discussed along with some considerations of the state of NOS research.

Synthesis of Variations in Nature of Science (NOS) Among Adult Learners

Joseph Watts*, University of Florida, USA
Kent Crippen, University of Florida, USA

ABSTRACT
Empirical research involving adult perceptions of the nature of science (NOS) indicates that while NOS research has primarily emphasized pre- and in-service K-12 teachers, an analysis of NOS elements across the literature suggests commonality with non-teacher specific studies. While teacher-focused andragogy regarding NOS beliefs holds value, adult learners' perceptions of NOS are not limited to a single educational ecosystem. For instance, science laboratory environments in teaching hospitals have adult learners interacting in an educational

manner. This systematic review and synthesis of empirical peer-reviewed research was conducted in order to identify the most relevant theories with existing empirical research that examines adult participant beliefs about NOS in authentic research environments. In doing so, the results offer guidance for an appropriate framework for a research agenda for studying science education as it occurs in broader applications.

Nature of Science Assessment Efforts: Interplay Between Contemporary Frameworks and Curricular Tensions

Alex Sobotka*, Texas A&M University, USA
Michael Clough, Texas A&M University, USA

ABSTRACT
While scholars have long called for improved science instruction, they have foregrounded different curricular priorities as part of major reform efforts (Yeager, 1992; DeBoer, 2019). These reform efforts have long been rife with persistent, interrelated tensions driven by cultural forces. Scholars, policymakers, and other stakeholders have engaged in back-and-forth shift between science for all and science for future scientists. Of course, reform advocates do not treat views in tension as mutually exclusive, nonetheless foregrounding positions has consequences. One manifestation of these consequences is another tension pitting breadth of learning against depth. Situated within the history of science education, or borrowing from its language, the nature, history, and philosophy of science, as deemed relevant for science education efforts face a similar tension of breadth vs. depth. This investigation seeks to examine the extent historical NOS assessment efforts have been captured by contemporary framings of NOS in science education and reoccurring curricular tensions in science education. Stakeholders of the nature, history, sociology, and philosophy of science need to retain a vision of the breadth of the NOS while keeping a focus so that teachers, administrators, and policymakers are not left adrift.

Strand 15: Policy, Reform, and Program Evaluation
Symposium: Elementary Science and Teacher Education Standards in the U.S.: Implementation and Future Directions
4/19/23, 10:20-11:50, Salon A4 (LL)

Elementary Science and Teacher Education Standards in the U.S.: Implementation and Future Directions

Katie Brkich, Georgia Southern University, USA
Terrance Burgess, Michigan State University, USA
Iliana De La Cruz*, Texas A&M, USA
Melissa Luna, West Virginia University, USA
TJ McKenna, Boston University, USA
Alesia Mickle Moldavan, Georgia Southern University, USA
Bailey Nafzinger, Georgia Southern University, USA
Christina Schwarz, Michigan State University, USA

Concurrent Session 4, 4/19/23, 10:20-11:50

Meenakshi Sharma, Mercer University, USA
Mary Starr, Michigan Math and Science Leadership Network, USA

ABSTRACT
The unfolding of the Next Generation Science Standards and other science education standards through school systems across the United States has impacted what science should be taught and how teachers should be prepared. This proposal takes stock of elementary science education standards across the U.S. and how states are implementing teacher education standards to prepare elementary teachers for those standards. Symposium presenters will share research on the current status of elementary science standards in the United States and cases of elementary science and teacher education standards from states within the Northeast, South, Mid-Atlantic, and Upper Midwest. This symposium asks: How have states have implemented these standards? What do those standards look like? What do they foreground? Where might we go in the future? Knowledge of the efforts made by states to revamp and communicate science learning standards is imperative if the field wishes to prepare effective science teachers and scientifically literate, thriving children across the nation. Our goal is to develop some communal understanding of these standards and determine productive outcomes such as resource repositories and networks that could bridge state-specific goals and challenge systemic boundaries that have historically limited student access to high-quality science instruction, especially for marginalized students.

Concurrent Session 5
4/19/23, 13:00-14:30

Publications Advisory Committee
Sponsored Session: Publishing, Reviewing, and Writing for JRST
4/19/23, 13:00-14:30, Salon A5 (LL)

Publishing, Reviewing, and Writing for JRST

ORGANIZERS
Felicia Mensah, Teachers College, Columbia University, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA
Li Ke, University of North Carolina at Chapel Hill, USA

PANELISTS
Lucy Avraamidou, University of Groningen, Netherlands

ABSTRACT
The Journal of Research in Science Teaching is the official journal of NARST: A global organization for improving science education through research. As a premier journal in the field with the largest impact factor, we rely on our associate editors, reviewers, and authors to facilitate convincing research consistent with the highest standards of varied theoretical traditions. In this session, we present an overview of important factors in writing and reviewing for JRST. As Editors, Troy Sadler and Felicia Moore Mensah along with Managing Editor Li Ke will explain the processes that JRST uses to facilitate peer review and make publication decisions. 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 also 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 1: Science Learning: Development of student understanding
SC-Organized Paper Set: Uncertainty and Sensemaking in Science Classrooms
4/19/23, 13:00-14:30, Salon C1-2 (LL)

A Bayesian Approach to Making Sense of Uncertainty in the Science Classroom

Marcus Kubsch*, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Joshua Rosenberg, University of Tennessee, USA
Eric-Jan Wagenmakers, University of Amsterdam, Netherlands
Mine Dogucu, University of California, USA

ABSTRACT
Uncertainty is ubiquitous in science, but scientific knowledge is often represented to the public and in educational contexts as certain and immutable. This contrast can foster dis- trust when scientific knowledge develops in a way that people perceive as a reversals, as we have observed during the ongoing COVID-19 pandemic. Drawing on research in statis- tics, child development, and several studies in science education, we argue that a Bayesian approach can support science learners to make sense of uncertainty. We provide a brief primer on Bayes' theorem and then describe three ways to make Bayesian reasoning practi- cal in K-12 science education contexts. There are a) using principles informed by Bayes' theorem that relate to the nature of knowing and knowledge, b) interacting with a web-based application (or widget—Confidence Updater) that makes the calculations needed to apply Bayes' theorem more practical, and c) adopting strategies for supporting even young learners to engage in Bayesian reasoning. We conclude with directions for future research and sum up how viewing science and scientific knowledge from a Bayesian perspective can build trust in science.

Conceptual Framework for Incorporating Student Uncertainties Into Science Learning
Ying-Chih Chen, Arizona State University, USA
Jongchan Park*, Arizona State University, USA
Emily Starrett, Arizona State University, USA
Michelle Jordan, Arizona State University, USA
Carlos Meza-Torres, Arizona State University, USA

ABSTRACT
Researchers have argued for incorporating the way of knowing in scientific practices in classroom activities. One research strand has suggested utilizing students' uncertainties as resources for developing scientific knowledge. Some empirical research investigated the role of uncertainties in driving classroom activities productively, but little research has examined conceptual foundations that gives practical implications of utilizing students' uncertainties. This paper examines when students feel uncertain by investigating four different cognitive sources (or conditions) that cause content and/or epistemic uncertainties. In addition, this paper suggests three dimensions (or indices) that can be referred to prioritize student uncertainties that emerge during scientific inquiries. The conceptual examination of these two aspects is practically useful because different sources of uncertainties need different supports/ interventions to be resolved and not all uncertainties are desirable to deal with within limited internal (e.g., students' efforts and motivations) and external resources (e.g., time). Possible future research is suggested based on the practical implications of the conceptual framework.

A Case Study of Undergraduate Biology Students' Engagement in Blended Sensemaking During Mathematical Modeling Tasks
Desi*, University of Minnesota, USA
Gillian Roehrig, University of Minnesota, USA
Anita Schuchardt, University of Minnesota, USA

ABSTRACT
Engaging in blended sensemaking – using science sensemaking to support mathematics sensemaking or vice versa – has a positive impact on student scientific understanding and problem solving skills. However, prior works have only examined whether blended sensemaking occurs by individual students, not how blended sensemaking occurs when students are working collaboratively in mathematical modeling tasks and the types of sensemaking involved. This case study investigated how blended sensemaking is distributed between two individuals working in a pair to mathematically model the rate of population growth. The Sci-Math Sensemaking Framework was used to identify the types of sensemaking. This study found that the selected pair engaged in individual and shared blended sensemaking. The shared blended sensemaking sometimes continued over several conversational turns. Moreover, students built on one another's sensemaking to generate greater understanding of the phenomenon or the equation. These findings open up the interesting possibility that one benefit of active learning might be to provide opportunities for sharing of sensemaking resources. This new lens could be used to distinguish between active learning tasks and group structures that are more or less effective.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: The Role of Sensemaking in Learning Science
4/19/23, 13:00-14:30, Salon C7-8 (LL)

Exploring opportunities for Students' Sensemaking Across Investigation Types in a Storyline Curriculum

Sage Andersen*, The University of Texas at Austin, USA
Karina Méndez Pérez*, The University of Texas at Austin, USA
María González-Howard*, The University of Texas at Austin, USA

ABSTRACT
Current reform-oriented documents (e.g., NRC 2012) and standards (e.g., NGSS, 2013) advocate for all students (Lee et al., 2014) to develop deep understandings of natural phenomena by engaging in practices that authentically represent what is done by individuals and groups across the sciences (e.g., planning and carrying out investigations, developing and using models, and analyzing and interpreting data) (Osborne, 2014). Central to sensemaking work is students' engagement in the science practice of planning and carrying out investigations, which provides students opportunities to iteratively and systematically explore phenomena as they work to co-construct new knowledge (Windschitl, 2017). While this science practice may, on the surface, appear to already be common in science classrooms, this fundamental shift towards students being responsible for the sensemaking inherently calls into question the ways in which investigations have typically been used for science learning. In this study, we sought to explore how a teacher enacted a storyline curriculum with his students in which investigations took on the purpose of either exploring or explaining an anchoring phenomenon. Findings shed light on how the teacher's enactment fostered or constrained opportunities for student sensemaking across different types of investigations in a storyline curriculum.

Supporting the Enactment of Ecological Concepts in Sense-making of Ecological Phenomena

Heesoo Ha*, Center for Educational Research, Seoul National University, Korea, Republic of
Yunhee Choi, Ewha Womans University, Korea, Republic of

ABSTRACT

Scientific knowledge is a primary resource that scientists use to shape their sense-making activities, and supporting students' adaptation of scientific knowledge can enhance their ability to make sense of the natural world. This study aims to examine how ecological concepts are enacted in students' sense-making of ecological phenomena and to identify teaching strategies to support students' enactment of such concepts. This study adapted the categorization of ecological concepts as natural, functional, and integrative according to how they are used in ecological research. With this foundation, authors examined a sensemaking activity that was implemented in a science club in a middle school. The goal of this activity was to make sense of ecological phenomena that were meaningful to the students as well as scientifically valid. Video recordings and transcriptions of the activities were analyzed as the main data sources. The analysis results reveal how different types of ecological concepts are enacted in sensemaking and illustrate teaching strategies to support students' enactment of different ecological concepts. Based on these findings, authors discuss cognitive support to expand the resources that students can use in sensemaking and the importance of domain-specific knowledge enacted in sensemaking of the natural world.

Sensemaking as a balance between dialogic tension and making sense

Ylva Hamnell-Pamment*, Lund University, Sweden

ABSTRACT

To provide classroom equity in terms of student achievement and reach government standards for sensemaking, it is important to investigate how teachers can sustain sensemaking practices in their classrooms. In this study, conversation analysis was used to study videotaped student-teacher dialogues at upper-secondary school practical lessons in chemical equilibrium. Common patterns of interaction were found in four experienced teachers' sensemaking dialogues with students. The data show how the teachers use inherent components of sensemaking in order to create a balance between dialogic tension and the co-creation sense to sustain sensemaking dialogues in the classroom. The results of the study can be used to promote achievement in equity through the modelling of sensemaking practices for teachers and teacher educators.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set: Patterns of Participation in Youth Informal Science Learning
4/19/23, 13:00-14:30, Blvd C (L2)

Strategies for broadening participation of historically underrepresented groups: A meta-synthesis of informal STEM education programs

Bobby Habig*, American Museum of Natural History, USA

Franny Geller, CUNY, USA
Preeti Gupta, American Museum of Natural History, USA
Jennifer Adams, University of Calgary, Canada
Mandë Holford, CUNY Hunter College, USA

ABSTRACT
A critical challenge facing educators is to understand what motivates youth, especially those from historically underrepresented groups, to persist in a STEM trajectory. To address this challenge, the goal of this study was to perform a meta-synthesis of research on youth participants of informal STEM programs. The research addressed two major questions: (1) How and to what extent do informal, out-of-school time STEM learning experiences impact participants' awareness, interest, and engagement in STEM majors and careers? (2) What are the program design principles, technology-based innovations, theoretical underpinnings, and best practices of rigorously designed informal STEM programs that exhibit exemplary evidence of impact that can be adopted by STEM practitioners to maximize impact and broaden participation of underrepresented groups? We used two validated rubrics to identify studies that exhibit exemplary research design and evidence of impact. In a comprehensive review of over 600 papers, we found that long-term participation in informal science education programs was positively associated with broadening participation in STEM and that the apprenticeship model was effective for attracting and retaining students in STEM trajectories. Our findings suggest that informal STEM programs play a critical role in fostering equity and for motivating youth to persist in a STEM trajectory.

Nature Capital Effects on Middle School Nature Identities
Laura Wheeler*, Utah State University, USA
Kathy Trundle*, Utah State University, USA
Rita Hagevik*, University of North Carolina Pembroke, USA
Katherine Vela, Utah State University, USA
David Joy, Wahlquist Jr. High School, USA
Michelle Parslow, Utah State University, USA

ABSTRACT
Goals for science education include helping students understand and appreciate the natural world. Students, however, are not getting outside in nature, which presents a barrier to this goal. This nature-deficit disorder raises some serious concerns for the physical, mental, and emotional health of students, as well as their connection to and care for nature and the world. Analyzing data from a nature interest and gardening access survey with middle-school students supported a significant relationship between parents encouragement for their children to spend time outdoors and students feeling at peace and wanting to care for nature. We found a positive significant relationship between time spent gardening and interest in nature. These results indicate that middle -school students who have higher nature capitol also have higher nature interest and identities. Nature capital as a form of STEM capital is not equitably distributed; school gardens, clubs, and botanical gardens provide access points for students who do not have home access or parental encouragement to spend time in gardens. Students who have spent time in gardens can be encouraged to develop their nature identities and

STEM identity. Future research should consider nature identity in relationship to and as a part of STEM identity formation.

Pipeline Schmipeline: Exploring Youth Pathways in Science

Anna MacPherson*, American Museum of Natural History, USA
Rachel Chaffee, American Museum of Natural History, USA
Peter Bjorklund, University of California San Diego, USA
Alan Daly, University of California San Diego, USA
Jennifer Adams, University of Calgary, Canada
Preeti Gupta, American Museum of Natural History, USA
Karen Hammerness, American Museum of Natural History, USA

ABSTRACT
Increasing diversity in science, technology, engineering, and math (STEM) education and industries is essential; research on students' pathways to and within STEM may contribute to our understanding of how to change institutions to achieve diversity. We have been following students who completed an out-of-school mentored science research program since 2017. This year, 385 responded to an alumni survey designed to collect data about their location along their pathway, constructs related to the pursuit of a pathway (e.g., science identity prominence, belonging, and experience with microaggressions), and demographic information. We found that participants in STEM fields identifying as women and gender non-conforming experienced higher levels of microaggressions than men; we did not find significant differences across ethno-racial groups. We found high levels of science identity prominence and academic and professional flourishing regardless of reported major or field; evidence supporting a more expansive view of STEM participation. By measuring constructs not typically measured in pathways research and endeavoring to design items and scales using an intersectional approach, we are pushing against the problematic pipeline metaphor that dominates in STEM persistence literature.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Approaches to Exploring Learning and Teaching about socio-scientific issues
4/19/23, 13:00-14:30, Salon A2 (LL)

Assessing preservice science teachers' socioscientific argumentation

Moritz Krell*, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Carola Garrecht, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Nina Minkley, Ruhr-Universität Bochum, Germany

ABSTRACT
This study assessed preservice science teachers' (PSTs) socioscientific argumentation (SSA) in moral-ethical dilemmas. More specifically, two challenges of assessing SSA are addressed: the influence of context on respondents' performance and the identification of appropriate

category systems for performance interpretation. 40 PSTs responded to four moral-ethical dilemmas, and their responses were qualitatively analyzed using two established category systems (interrater agreement: moderate to almost perfect). On average, the participants reached a medium level of SSA, i.e., they provided justifications with simple grounds or justifications with a change of perspective, respectively. Related to the relevance of context, a significant difference (large effect size) between the participants' levels of SSA was only found for two dilemmas, and no significant correlations were found between the levels of SSA in the four dilemmas. Individual differences might explain these findings, resulting in so-called 'context-person-valences' (e.g., interestingness). These valences are not characteristics of a context itself but arise as an interaction between person and context, influencing their argumentation. Related to the relevance of the category system, a significant difference (large effect size) in the levels of SSA between the two category systems was found. This finding indicates the importance of carefully choosing an appropriate category system.

Understanding Preservice Teacher's Knowledge and Emotions Related to Climate Change

Catherine Bohn-Gettler*, College of St. Benedict, USA
Diana Fenton*, College of St. Benedict, USA
Carly Mastrian, College of St. Benedict, USA

ABSTRACT
Climate change knowledge is essential for science educators at all levels, hence its inclusion in many K-12 state science standards. Although education is one of the most important strategies for mitigating climate change, emotions about climate change can impact whether the topic is taught. The present study examines preservice teachers' knowledge and emotions about this controversial topic of climate change. Elementary preservice teachers participated in a science content or pedagogy course that addressed misconceptions, knowledge, and teaching strategies related to climate change. Although participants' knowledge levels of climate change were low, there was significant growth over the semester – especially for knowledge related to mitigating climate change. Participants' feelings of anger, frustration, and hopelessness related to teaching climate change also decreased. The results suggest that intentional instruction on climate change is needed, and researching strategies to address misconceptions about climate change is essential for preservice teachers to increase knowledge and decrease negative emotions, which could then impact their future students.

Using News Articles about COVID-19 as a Context for Promoting Pre-service Science Teachers' Argumentation Skills

Resmiye Uzun*, Hacettepe University, Turkey
Metin Şardağ, Van Yüzüncü Yıl University, Turkey
Gültekin Çakmakcı, Hacettepe University, Turkey

ABSTRACT
The purpose of this research is to enhance the quality of argumentation of future science teachers by using media coverage of the Covid-19 pandemic. To achieve this, a 13-week educational intervention sequence was developed. The research was designed as an interventional mixed method approach. While the qualitative data set was obtained from the

written arguments and observation notes, the quantitative data were obtained from the pre-posttest application. Two independent researchers coded the qualitative data to assure reliability. Participants of this study are 22 female and 5 male, senior year university students. Toulmin's argumentation model (1958) constitutes the theoretical framework of this study. Besides, for assessing the quality of the participants' written arguments analytical framework developed by Erduran, Simon, and Osborne (2004) was used. The results revealed that the developed intervention approach could help pre-service instructors improve their reasoning skills. Furthermore, the participants' abilities to assess the arguments in the science news increased, and they were able to construct stronger written arguments by the end of the intervention. Pairwise comparisons demonstrated that the mean changes from pretest to posttest were statistically significant. It is considered that this research will be a guide for science curriculum developers, science teachers, and researchers.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Exploring How Preservice Teachers Engage with Engineering Practices Across Different Contexts
4/19/23, 13:00-14:30, Salon A3 (LL)

"I 100% see myself teaching engineering": An exploration of elementary PSTs' intentions to integrate engineering

Min Jung Lee*, Old Dominion University, USA
Pilar Pazos-Lago, Old Dominion University, USA
Jennifer Kidd, Old Dominion University, USA
Kristie Gutierrez, Old Dominion University, USA
Francisco Cima, Old Dominion University, USA
Stacie Ringleb, Old Dominion University, USA
Krishnanand Kaipa, Old Dominion University, USA
Orlando Ayala, Old Dominion University, USA

ABSTRACT
National and state standards require elementary teachers to teach engineering in their classrooms. In response to this requirement, a growing number of teacher education programs are focusing on helping preservice teachers (PSTs) develop the knowledge and skills required to integrate engineering into their instruction (Cevik et al., 2020; Author et al., 2020; Author et al., 2020; Portsmore et al., 2019; Bers & Portsmore, 2005; Tank et al., 2017). However, little is known about how these programs influence PSTs' intention to integrate engineering into their future classrooms. This mixed methods study investigates how participation in a cross-disciplinary collaboration during teacher preparation affected PSTs' intention to integrate engineering as well as the relationship with teaching self-efficacy and beliefs about K-12 engineering. Results from a mediation analysis revealed that participating in the cross-disciplinary collaboration positively predicted PSTs' intention to integrate engineering both directly and through teaching self-efficacy and beliefs about K-12 engineering. The qualitative analysis suggests that PSTs' beliefs about K-12 engineering reflect both perceived benefits to

elementary students and contextual barriers to engineering integration. We believe this study shows how exposing PSTs to a cross-disciplinary collaboration to teach engineering lessons during their academic preparation contributes to their future intention to integrate engineering.

Preservice Elementary Teachers' Understandings of Science and Engineering Practices as Vehicles for Sensemaking

Amy Ricketts*, California State University, Long Beach, USA
Michele Korb*, California State University, East Bay, USA

ABSTRACT

As we reflect on the impact of the NGSS over the last decade, it is important to consider how educators are taking up the science and engineering practices (SEPs) as vehicles for student sensemaking – as opposed to a set of hands-on, teacher-directed procedures for students to follow. To that end, this case study investigates the question: To what degree, and in what ways did preservice elementary teachers demonstrate an understanding of science and engineering practices as vehicles for student sensemaking in their science methods coursework and student teaching? To answer this question we analyzed the written work that 19 preservice elementary teachers' (PSETs) produced in their elementary science methods course, as they planned for and reflected on teaching a science lesson in their student teaching classrooms. Our findings suggest that PSETs are indeed capable of understanding science and engineering practices (SEPs) as vehicles for sensemaking, and that this understanding may be supported by: 1) requiring PSETs to explicitly address sensemaking when talking and writing about engaging students in the SEPs, 2) introducing sensemaking at various "grain sizes," and 3) providing opportunities for PSETs to plan, implement, and reflect on science lessons with children, using an analytical lens of sensemaking.

Preservice Middle Grades Teachers Supporting English Learners in Science and Engineering

Romola Bernard*, University of North Georgia, USA
Lorraine Ramirez Villarin, University of North Georgia, USA
Max Vazquez Dominguez, University of North Georgia, USA
Sheri Hardee, University of North Georgia, USA
Magda Guzman, University of North Georgia, USA
Maggie Lewis, University of North Georgia, USA
Victoria Hunter, University of North Georgia, USA

ABSTRACT

As part of an intensive summer session science methods course, preservice teachers participated in a month-long immersive summer program for rising 4th through 8th grade English Learners (ELs). The science methods course provided a unique opportunity for preservice teachers to expand their field teaching experience in both science and engineering, while they collaborated with colleagues from diverse backgrounds to create and instruct in an environment that nurtures ELs. Instruction was organized around two disciplinary core ideas for each grade level. Each core idea was taught over 6 _ days, representing a half session, with a science focus in the mornings, and an engineering focus in the afternoons. Preservice teachers were assigned to co-teaching teams with candidates from diverse backgrounds. The co-

teaching instructional team implemented strategies to meet eight competencies that supported ELs' cultural and linguistic needs. The three dimensions of learning for the Next Generation Science Standards were foundational to the 5-E science lessons and the 7-step engineering design lessons preservice teachers implemented.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Science Teacher Learning about Science Learning in Social Contexts
4/19/23, 13:00-14:30, Waldorf (L3)

Exploring Urban Educators' Entry and Early Trajectories Into Place-Based and "Place-Powerful" Teaching and Learning.

Roberta Hunter*, Michigan State University, USA
Gail Richmond, Michigan State University, USA

ABSTRACT
Place-based education (PBE) takes many forms, but at its core it is characterized by teaching and learning that connects the classroom with the community; that takes advantage of the affordances of the site and surrounding community; that takes advantage of the affordances of the site and surrounding community; and that addresses local issues that are meaningful to students. The research presented here describes the implementation of PBE by three teachers who participated in a two-part professional development program focused on supporting urban elementary teachers in teaching science outdoors. Using multiple case study methods, through interviews and observations, we examine whether the place-based science is also place-powerful, emphasizing the narratives of a place, told or re-told by an individual which tightly bind the social, cultural, and physical aspects of that place and which generate a deep and lasting impact on the individual. We also look at personal and school factors that influence how the three teachers approach teaching outdoors.

Teachers' meaning making of cultivating learners to become scientifically literate citizens

Mandi Collins*, University of Nevada, Reno, USA
Elizabeth de los Santos, University of Nevada, Reno, USA

ABSTRACT
In this qualitative, multiple-case study, we explore middle school teachers' meaning-making of cultivating learners to become scientifically literate citizens. The theoretical framework utilized for this study explores teachers' mutual engagement of pedagogical content knowledge within a community of practice which may contribute to how teachers make meaning of cultivating learners to become scientifically literate citizens. Teacher participants, from a public sixth through eighth-grade charter school, consisted of two teachers from each of the subject areas ELA, science, and social studies. Data collection consisted of semi-structured individual interviews, individual think-aloud, and focus group think-aloud with two interdisciplinary teams of teachers. Findings illustrate that teachers' development of mutual engagement, within a

community of practice, resulted in defining scientifically literate citizenship as a culmination of being knowledgeable about science content, being able to apply skills to problem solve, and possessing character attributes. These findings are significant to middle grades education as pre-adolescence is significant in the development of civic dispositions, such as being scientifically literate. Additionally, middle-grade philosophies foster engaging students in an interdisciplinary curriculum that is challenging, exploratory, and diverse.

Middle Grades STEM Teachers' Socioscientific Perspective Taking Concerning Socioscientific Issues

Melanie Kinskey*, Sam Houston State University, USA

ABSTRACT

Science education researchers have advocated that socioscientific issues (SSI) instruction is an approach to teaching science that improves scientific literacy skills among K – 12 students. For the successful enactment of SSI-based instruction to occur, teachers need knowledge and skills related to socioscientific perspective taking (SSPT). The three components of SSPT: (1) Engagement; (2) Emic/etic shifts; and (3) Moral context have framed the data collection and analysis in this study. In the current work, the researcher explored how middle grades teachers displayed elements of SSPT as they participated in discussions concerning SSI during a master's level earth science course. Data were collected in the form of pre- and post-module discussion responses and replies to colleagues and were analyzed using deductive codes aligned with the SSPT constructs. Findings suggest the construct of SSPT where participants displayed the most growth after engaging with course content and interacting with their colleagues was in their ability to display emic/etic shifts concerning the SSI. This study contributes empirical evidence concerning developing teachers' SSPT and has implications for how science education researchers might approach leveraging constructs of SSPT in professional learning experiences for teachers being prepared to enact SSI-based lessons.

Description of personal preconceptions and dispositions about climate change in science teachers in Chile

Veronica Abasto*, Universidad Catolica de Valparaiso, Chile
Antonia Larrain, Universidad Alberto Hurtado, Chile
Hernan Cofre, Universidad Catolica de Valparaiso, Chile

ABSTRACT

This research aims to describe the knowledge, preconceptions, and personal dispositions on climate change in a group of Chilean science teachers, as well as the impact of a professional training course on climate change teaching on these aspects. The study has a quantitative methodology, is of an exploratory, descriptive, and transversal design in which a Climate Change Questionnaire was applied to a group of 46 teachers pre-service and in-service. From them 19 teachers that participated in a professional training course teachers responded the instrument also at the end of the course as a post-test. The results show that the whole group of teachers have moderate knowledge about climate change, they present some preconceptions such as confusions about greenhouse gases, solar radiation and the false relationship between ozone layer thinning and the greenhouse effect. This knowledge

correlates with dispositions towards actions that mitigate climate change and teachers' science self-efficacy. In addition, it is found that the professional development course contributed to the improvement of the participants' knowledge on climate change and improved their dispositions to contribute to actions to mitigate the effects of climate change.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set: Expanding technology-enhanced pathways for science assessment
4/19/23, 13:00-14:30, Salon C3-4 (LL)

Automatically Assess Elementary Students' Hand-Drawn Scientific Models Using Machine Learning: Is It Possible?

Tingting Li*, Michigan State University, USA
Feng Liu, Michigan State University, USA
Joseph Krajcik, Michigan State University, USA

ABSTRACT
Scientific modeling has been recognized as a high-leverage practice to support students' knowledge-in-use building. Yet, constructing scientific models challenges young students and teachers, which is partially due to the complexity and diversity that constructed models bring to model evaluation that is time-consuming and demanding and increases teachers' workload. Although efforts have been made to explore scoring approaches to automatically assess students' constructed responses, most existing studies apply machine learning (ML) to automatically grade student written text-based constructed responses at the secondary or postsecondary level. To date, no study explores automatic scoring of elementary students' hand-drawn models for 3D assessment tasks, which is more challenging because they are highly abstract and exhibit large intraclass deformations. We applied ML to automatically score elementary students' hand-drawn scientific models for measuring knowledge-in-use. We collected 2076 students' hand-drawn models of a 3D task distributed across 107 different classes from four regions in Michigan across two years. We used the human-scored responses to develop ML algorithms and train the computer. We used new data to validate the algorithm. We employed data augmentation technique to improve the accuracy. Preliminary results show great potential of the algorithm to produce a high-performing model for automatic scoring.

Exploring student responses in the context of automated-generated feedback on science reasoning patterns

Dante Cisterna*, ETS, USA
Lei Liu, ETS, USA
David Baidoo-Anu, Queen's University, Canada
Devon Kinsley, ETS, USA
Yi Qi, ETS, USA

ABSTRACT
Studies on feedback mention the importance of providing specific, goal-aligned, and actionable information to students about their performance. Machine learning techniques can be used to provide automated feedback to students so they can guide their decision-making process. This study explores how students made sense of the feedback provided on science reasoning patterns to analyze and refine their responses, in ways that reflect one or more dimensions of the Next Generation Science Standards. Drawing on an annotation framework for student reasoning patterns in an ecosystem constructed-response item, we explored 45 middle- and high-school students' interpretation of an automated feedback tool, which highlights the reasoning patterns in the response and provides descriptions and prompts for improvement. Results show that the automated feedback tool helped most students to identify the components of their answers and, in many cases, they refined them to include more evidence. When analyzing their responses, students used different strategies to refine them, as they paid attention to feedback components such as the description of reasoning patterns or the prompts for improvement. This study sheds light on the development of assessment tools that include enhanced and actionable feedback in science through the use of automated annotation tools.

Scientific modeling of the solar system (SMSS) version 2.0: Developing an instrument from four-element process
Letong Zhang*, Beijing Normal University, China
Jing Lin, Beijing Normal University, China
Weiwei He, Beijing Normal University, China

ABSTRACT
Scientific modeling (SM) has been recognized as a core scientific practice. Previous studies have examined students' SM practice by evaluating students' SM products, but much less is known about the challenges students encounter in the complex process. This study developed a measurement instrument for procedural observation of students' SM performance from the four-element process. A series of interrelated but independent items situated in the solar system scenario was developed to coherently measure students' performance coherently. After two rounds of field tests, the reliability and validity of the instrument were guaranteed via EFA and CFA. This study may expand the quantitative analysis approach of SM with large samples to diagnose the challenges encountered by students. The validated instrument is valuable for improving SM teaching in a data-driven and evidence-based way. Further, the results of different difficulties of the four elements might provide a clue for further research on the cognitive mechanism of the SM process. Findings also suggest that students should have more opportunities to engage in revising their own models through model evaluation, rather than just using models provided by teachers or textbooks, to advance their SM proficiency.

Assessing curriculum representations in pre-service physics teachers' teaching reports with machine learning
Peter Wulff*, Heidelberg University of Education, Germany
Lukas Mientus, University of Potsdam, Germany
Anna Nowak, University of Potsdam, Germany

Concurrent Session 5, 4/19/23, 13:00-14:30

Andreas Borowski, University of Potsdam, Germany

ABSTRACT
The science disciplines can be represented by a well-structured, interconnected, and hierarchical body of knowledge. This body of knowledge is typically condensed into a curriculum that functions as a guideline for instructors to design science lessons. However, each individual science teacher interprets curriculum differently and instruction is aligned to various degrees to the normative curriculum. Consequently, it would be desirable for the science education community to have assessment tools that can attend to individual science teachers' accounts of curriculum implementations, and corporate the normative curriculum as a grounds for comparison. In this line, computerized tools such as machine learning gained traction in the science education research community, because machine learning enables assessment of complex constructs and relationships in unprecedented ways. In this study we explore potentials of machine learning to assess representations of curriculum in physics teachers' teaching accounts. We apply a bottom-up approach where clusters in physics teachers' teaching accounts are extracted that align with representations of physics curriculum. We also apply a top-down approach, where teachers' teaching accounts are analyzed vis-à-vis a normative curriculum extracted from a physics textbook. We critically discuss ways in which these approaches can enhance assessment of curriculum in science education research.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set: Consequential Arrangements for Becoming: Considering Identity Work in STEM Across Social, Institutional, and Practice Spaces
4/19/23, 13:00-14:30, Salon A1 (LL)

Weaving in-and-out of School Experiences to Craft STEM Identities
Carrie Allen*, University of North Texas, USA

ABSTRACT
Out-of-school time (OST) experiences suggest promise for providing youth with expanded notions of and avenues for becoming in STEM (Author, 2020; Calabrese Barton et al., 2013). This is particularly the case for girls of color (Adams & Gupta, 2013) who are often positioned less favorably than their white, male peers (Authors, 2016; Nasir & Hand, 2006) with respect to STEM, and who are met with robust stereotypes regarding who is recognized as STEM oriented. Yet, OST experiences are often isolated from STEM learning experiences in school and can, furthermore, be in conflict with school experiences that tend to constrain identity work (Authors, 2016) and marginalize youth underrepresented in STEM fields. In this paper, we examine the ways young women of color in STEM leveraged available identity resources across OST, family, and school to craft STEM identities during high school and into college.

Using familial STEM identity to understand identity development through social units
Remy Dou*, Florida International University, USA
Heidi Cian*, Florida International University, USA

ABSTRACT
Using case study data, we illustrate the need for a more comprehensive model of STEM identity development that accounts for the STEM affiliation of youths, their caregivers, and siblings–not as a collection of individuals but as a coherent and functional unit. We introduce the concept of familial STEM identity as a framework on which to expand STEM identity development theory, particularly as it relates to learners whose social identities are tightly embedded in family relationships, values, and culture. We emphasize the value of familial STEM identity in the context of diversification of STEM fields and formal and informal STEM programming with related goals. We argue that such reframing is especially necessary when STEM institutional contexts drastically differ from those with which youths are comfortable outside of the institution. This work further implies that observation tools and program assessments should be designed to gauge the context's compatibility with learners, reconstituting analytical lenses on the construction of learning contexts' fit for youths and families with diverse experiences and insurgent dispositions, rather than on learners' fit for learning contexts.

"Those kinds of students": Designing for Teachers' Sensemaking of Students' STEM Identities
Sara Heredia*, University of North Carolina at Greensboro, USA
Carrie Allen, University of North Texas, USA

ABSTRACT
Students' STEM identity development is generally not part of the ways in which science teachers assess their students' learning. Rather, science teachers focus on students' conceptual development toward scientific explanations of complex phenomena. However, studies of students' STEM identity development name science teachers as important actors in how and in what ways students develop STEM interest and identity. In this paper, we explore science teachers' sensemaking of students' STEM identity development in out-of-school science settings. We focus on two designed professional development resources - a data representation of students' STEM identity profiles and a pedagogical framework - to understand how they mediated science teachers' sensemaking about STEM learning as identity development. We found the tools supported science teachers to recognize and connect students' engagement in STEM activities to their STEM identity profiles and interests. We present examples of science teachers' productive sensemaking with these tools and the facilitation practices that supported it. We also address the limitations of each tool.

Contextual Cues of Learning Experiences and their Influences on Expressions and Development of STEM Identities
Heidi Cian*, Florida International University, USA
Remy Dou*, Florida International University, USA

ABSTRACT
Using what we have learned from college students and families in a Latine-majority city, we consider the contextualized nature of family STEM identity development. Particularly, we focus on how social group composition and institutional, social, and historical context intersect to

influence expressions of STEM identity in learning spaces. We attend to how these contextualized expressions extend to the development of STEM identity and perceptions of what it means to be a STEM person more broadly. We found that in both formal (e.g., classrooms) and informal (e.g., museums) learning spaces, many of our participants encountered institutional values and norms that reinforced a fact-based perception of what it means to participate in STEM. These values and norms were communicated through environmental visual cues and interactions modeled by institutional authorities. As such, learners reverted to these cues in these spaces, enacting STEM identities within their social groups in ways that valued knowledge of facts and expression of such knowledge through authoritative dialogic structures. We suggest that such expectations may present a unique challenge for youth and families who experience cultural conflicts with institutional authorities that present STEM in sociocultural contexts and forms not afforded them, particularly for families with recent immigration histories.

Informal STEM Education Spaces as Frames for Women's STEM Identity Stories
Roxanne Hughes, National High Magnetic Field Laboratory, USA
Amal Ibourk*, Florida State University, USA
Lauren Wagner, Florida State University, USA

ABSTRACT
Women represent less than one-third of the STEM workforce. This underrepresentation is due to various reasons, some of which are dependent on the salient identities that each girl/woman brings with them to STEM spaces. Research shows that girls begin to question whether they belong or can be successful in STEM during elementary and middle school due to perceptions that these fields are predominantly white and male, leading them to question whether they are (or can be) scientists and recognized as such by others. Informal STEM education (ISE) programs have been found to be influential in improving girls' science identity, by creating a third space for marginalized youth—including girls of all races—to connect school science and their daily lives and allowing them to begin to see themselves and be recognized by others as scientists. However, few studies have looked at the influence of ISE programs from middle school on women's STEM identity negotiations later in life. This study provides the story of one woman - Michelle - and the role that ISE programs across her life played on her STEM identity as a college senior.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Inclusion in k-12 Science Education: What does it look like? What can it look like?
4/19/23, 13:00-14:30, Salon A4 (LL)

What happens to the students at the margins? Inclusion at a time of curriculum reform.
Lydia Burke*, University of Toronto, Canada

ABSTRACT
Our study employed a Delphi approach (using sequential surveys interspersed with summarized feedback) to solicit and collate the opinions of 20 educational leaders regarding policies, practices, and pedagogies that support effective and inclusive STEM education (STEM was recently introduced into the regional Science & Technology curriculum). Each leader had expertise in formal and/or informal STEM education provision for learners from social groups that are underrepresented in STEM careers and STEM education pathways within the given region of an East-Central Canadian province. We found that, although regional and national government reports focus on the underrepresentation of girls/women in STEM, our participants cited income status and race as being even more impactful in influencing STEM education success for the learners they support. The participants tended to discuss marginalization in intersectional terms where many students face multiple conditions of disadvantage. Participants hotly debated the impact of outdated, Eurocentric educational traditions, and asserted the importance of centering educational planning on local, community-based understandings of the learners' needs and interests. From the study we derived a list of 6 consensus principles upon which equitable STEM education should be based and a list of 10 key prioritizations for program planning.

Linking Science and Literacy Through Multimodal Text Sets: Student Perspectives
William Romine*, Wright State University, USA
Heba Abdelnaby*, University of Missouri-Columbia, USA
Delinda van Garderen, University of Missouri-Columbia, USA
Tracey Milarsky, University of Missouri-Columbia, USA
Cassandra Smith, University of Missouri-Columbia, USA
Amy Lannin, University of Missouri-Columbia, USA
William Folk, University of Missouri-Columbia, USA

ABSTRACT
We present findings of a study examining the perceptions of students' (with and without disabilities) engagement with multimodal STEM text sets that were designed to support development of disciplinary literacy skills.

Downplaying Achievement and Retention of (HiS) in STEM! What can (CTCA) do in Logic Gate?
Olasunkanmi Gbeleyi*, Lagos State University, Nigeria
Peter Okebukola, Lagos State University, Nigeria
Ibukunolu Ademola, Lagos State University, Nigeria
Agbanimu Deborah, Lagos State University, Nigeria
Peter Esther, Lagos State University, Nigeria
Franklin Onowugbeda, Lagos State University, Nigeria
Bugoma Suwadu, University of Burundi, Burundi
Juma Shabani, University of Burundi, Burundi
Adekunle Oladejo, Lagos State University, Nigeria
David Byamungu, University of Burundi, Burundi
Fiacre Muhimpundu, University of Burundi, Burundi

ABSTRACT
The learning objectives for hearing-impaired students (HiS) are not different from normal students, but their learning approach is not the same. Learning materials for hearing-impaired students (HiS) should be made simple and equipped with necessary things that will boost meaningful learning. Therefore, the purpose of this study is to find out the effectiveness of the culturo-techno-contextual approach (CTCA), on hearing-impaired students (HiS) achievement and retention in the logic gate. Results obtained from the first phase revealed logic gate as one of the most difficult topics in computer studies. Next phase was guided by two research questions, participants are from the public junior secondary (equivalent to 8th grade) in Lagos State, Nigeria. About 47% of the respondents were males while about 53% were females. Logic gate achievement test (LGAT), retention, and an (HiSPCTCAIG) interview guide was used to collect data for the study. The data gathered was subjected to multivariate analysis of covariate (MANCOVA), and the results revealed a statistically significant difference in the methods used, univariate F (Pillai's Trace) was significant [$F=(1,98)=163.78$; $p<.05$], and retention [$F(1, 98) =206.03$; $p<0.05$]. From these findings, CTCA is capable of promoting meaningful learning among (HiS) in schools.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set: Assessment and Evaluation of Learning
4/19/23, 13:00-14:30, Salon C5-6 (LL)

Development And Usability Evaluation of an App for Inquiry-Based Science Education
Toma Bogdan*, University of Burgos, Spain
Meneses Villagrá Ángel, University of Burgos, Spain

ABSTRACT
Scientific inquiry, as well as the use of ICT resources, are regarded as appropriate and effective methodologies for teaching science. This proposal describes a 3D educational app for mobile phones and tablets that was designed to help teachers enact inquiry in the classroom. In Spain, a pilot study with 20 fifth-grade Primary School students revealed adequate usability scores. The proposed inquiry app is, therefore, regarded as a valuable resource for inquiry-based science education. Avenues for future endeavors include translation of the app into English and the evaluation of the impact of its use on variables of interest, such as conceptual learning or attitude development.

Social network analysis shows equal numbers of public, educators, and scientists within an online world
Lisa Lundgren*, Utah State University, USA
Man Zhang, Utah State University, USA

ABSTRACT
Characterizing who participates in and contributes to conversations with online social worlds can help extend our understanding of the science education ecosystem, including giving

insight into what kinds of communication works for whom and under what conditions. We describe methods for characterizing an online, scientific affinity space using three science-based hashtags: #ScienceTwitter, #AcademicTwitter, and #SciComm. Researchers applied an established framework to describe a subset of users who interacted with these hashtags (n = 1000) and analyzed the structure of the network during a one-month period. Social network analysis showed a highly dispersed network, but equal numbers of scientists, members of the public, and educators all equally controlling information flow. Using social network analysis and describing users with the social network gives a deeper understanding of the community and interactions within the space, which can lead to the development of better science communication efforts in the digital realm as well as establish a better corpus of user data for future efforts using machine learning to more quickly and accurately describe large communities.

Assessing an Online Module to Support Nature of Technology Learning of Preservice Teachers

Jerrid Kruse*, Drake University, USA
Marco Arreola, Drake University, USA
Mitch Klocke, Drake University, USA
Sarah Voss*, Drake University, USA
Isaiah Kent-Schneider, Drake University, USA

ABSTRACT
Using a design-based research approach, this study explored the efficacy of an online learning module leveraging a socioscientific issue (GPS tracking) to engage preservice teachers with nature of technology (NOT) constructs. By exploring participant responses to module questions as well as an assignment asking about inclusion of NOT outcomes for their future students, this study makes recommendations for improvement of the module studied with implications for NOT learning within SSI contexts more generally. Findings include that participants struggled with the evolutionary nature of technology and critical consciousness perspectives in the module and neglected to include critical consciousness and value-laden outcomes in their thinking about their future students.

Assessing students' motivation to learn in technology-enhanced science classes through a sociocultural lens

Tamar Ginzburg*, Technion - Israel Institute of Technology, Israel
Miri Barak, Technion - Israel Institute of Technology, Israel

ABSTRACT
There are numerous inequalities in education, yet there is an array of opportunities for shaping education systems for the global challenges of today's world. One such opportunity lies in utilizing technology to facilitate motivation through social participation to promote scientific literacy. The goal of this study was to examine whether and how technology-enhanced science learning may facilitate motivation to learn, from a sociocultural stance. The study utilized the sociocultural approach as a guiding lens, focusing on elementary school students in the US and Israel (English, Hebrew, and Arabic speakers). Interviews, observations, and self-reflections were analyzed to examine the cultural context of participation in joint activities that are

sensitive to students' cultural backgrounds. Findings show that science teachers are supportive of exposing young students to peers from diverse cultural backgrounds, viewing it as instrumental for 21st-century education. Technology was mentioned as supporting tools for developing connections between learners. Synchronous meetings between students from the different participating schools and countries revealed three levels of motivation, with the highest being observed during small cross-cultural group discussions. The study provides insights into how digital technologies can be utilized to facilitate culturally sensitive online learning environments for the promotion of motivation to learn science.

Strand 15: Policy, Reform, and Program Evaluation
SC-Organized Paper Set: Teacher Education
4/19/23, 13:00-14:30, Blvd A (L2)

The "Moneyball" Problem in Teacher Education: Predictor Variables to Build a Better Teacher

Joanne Olson*, Texas A&M University, USA
Allison Esparza*, Texas A&M University, USA
Syahrul Amin*, Texas A&M University, USA
Jacob Pleasants, The University of Oklahoma, USA
Iliana De La Cruz, Texas A&M University, USA

ABSTRACT
This study investigated three methods associated with teaching quality and long-term implementation of reform with teacher personality characteristics. Results indicated that the ASQ, STEBI-B, and TTI were not associated with teacher quality nor persistence in integrating long-term reform efforts. The broader problem remains in that the field may not yet be able to predict, in advance, individuals who will be successful in the classroom. Understanding the sustainability of professional development and teacher indicators is necessary if reform efforts are to be successful beyond professional development.

Results of an Impact Evaluation Study of Early Career Teachers Engaging in Summer Modeling Institutes

Sanlyn Buxner*, Planetary Science Institute, USA
Larry Horvath, San Francisco State University, USA
Bridina Lemmer, American Institutes for Research, USA
Melissa Yisak, American Institutes for Research, USA
Maya Bakerman, Planetary Science Institute, USA
Jennifer Nelson, San Francisco State University, USA

ABSTRACT
The practice of Developing and Using Models is described as an anchor practice to support student learning in other science and engineering practices. Teachers often struggle with developing their own understanding of what constitutes modeling as a practice as well as how to develop student's sophistication in understanding of this skill over time. This impact

evaluation study reports on outcomes for early career teachers who took part in summer modeling institutes in math and science supported by a broad multi-state program. Data were collected from 27 middle and high school math and science teachers who provided lesson plans, interviews, and classroom observations. After participating in the PD, 42% of participants lesson plans showed increased alignment to eliciting student ideas and increased evidence of incorporating some element of the science and engineering practice of modeling. The majority of the post PD videos showed student-directed elements of developing and using models and teachers providing opportunities for students to engage in modeling. In the interviews, teachers moved from talking about modeling as a strategy to letting students work with data and create models as a strategy. This research is important to other large professional development efforts that span multiple curriculum and sites.

Which Organizational Conditions Predict the Translation of Professional Development to Science Instructional Practice?

Kathryn Hayes*, California University East Bay, USA
Jessica Gladstone, Virginia Commonwealth University, USA
Brit Toven-Lindsey, UCLA, USA
Christine Bae, Virginia Commonwealth University, USA
Eric Nolan, California University East Bay, USA

ABSTRACT
Professional development (PD) provides support for elementary teachers struggling to implement equitable science instruction. Yet, teachers vary in their uptake and implementation of instructional practices advocated for in PD, variance which cannot be explained by a solely PD approach or teacher personal traits (e.g., self-efficacy). Organizational conditions need to be examined in how they shape professional learning to support teacher equity self-efficacy and science instruction. To meet this need, we conducted a path analysis to analyze survey data collected from third through fifth grade teachers participating in a three-year science education PD project. We examined how11 organizational conditions, drawn from the instructional capacity framework and other literature, predicted teacher self-efficacy and science instruction in the context of PD. Teacher professional impact, sense of autonomy in teachers' instructional practice, and policy alignment explained variance in teacher self-efficacy and reform-based instructional practices. Findings indicate that although participation in PD indirectly predicted teacher implementation of reform-based instructional practices (mediated by self-efficacy), this relationship became statistically non-significant when organizational variables were accounted for. These findings show the potential importance of teacher professionalism and sense of agency over commonly cited organizational conditions.

Nature of Engineering in the Framework and the Next Generation Science Standards

Hasan Deniz*, University of Nevada Las Vegas, USA
Erdogan Kaya, George Mason University, USA
Ezgi Yesilyurt, Weber State University, USA

ABSTRACT
In this study, we aimed to discern epistemic aspects of engineering (NOE aspects) relevant to K-12 engineering education from the Framework (NRC, 2012). We classified the epistemic aspects of engineering that we discerned from the Framework into 10 nature of engineering (NOE) aspects and reported how many times each NOE aspect was mentioned. We also reported how these epistemic aspects of engineering were reflected in grades K-2, 3-5, middle school, and high school Performance Expectations tables addressing Engineering Design. At the end, we made recommendations about how to teach NOE aspects in an explicit-reflective fashion while students are engaged in the engineering design process.

Social Event
Awards Dessert Reception
4/19/23, 14:45-16:15, Grand Ballroom (L2)

Please join us in the Grand Ballroom in celebration of recipients of the Distinguished Contributions to Research Award (DCRA), Early Career Research Award (ECRA, Outstanding Dissertations Research Award (ODRA), and NARST Fellows.

Concurrent Session 6
4/19/23, 16:40-18:00

Research in Artificial Intelligence-Involved Science Education (RAISE)
Sponsored Session: Research in Artificial Intelligence-involved Science Education
4/19/23, 16:30-18:00, Salon A5 (LL)

Research in Artificial Intelligence-involved Science Education

ORGANIZERS
Xiaoming Zhai, University of Georgia, Athens, GA, USA
Kent Crippen, University of Florida, FL, USA

PANELISTS
Joseph Krajcik, Michigan State University, USA
Knut Neumann, Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
Artificial Intelligence (AI) is increasingly applied in science education research to tackle challenging problems. The RAISE RIG aims to facilitate AI-involved research in science education and form a research community. We organized this poster session authored by researchers from seven universities and three partner institutions. The session will present nine science education projects that involve cutting-edge technology and applications of AI. Research covers diverse topics such as scoring algorithmic model development, examining students" knowledge-in-use, teacher interpretation and use of AI-based assessment reports, creating learning tools for both formal and informal learning, student identities, supporting students with learning disabilities, and automatically scoring teacher discourses. The research contributes to the technological, pedagogical, and epistemological aspects of science education, illustrates the diversity of perspectives and applications in the RAISE RIG, and represents the status-of-the-art research in this emergent research area.

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set: Disciplinary Knowledge and Technology in Science Classes
4/19/23, 16:30-18:00, Salon A4 (LL)

Lebanese Students' Reasoning of the Immune System in Grades 8 and 12
Ihsan Ghazal*, Texas Christian University, USA
Hayat Hokayem, Texas Christian University, USA

ABSTRACT
Research suggests that students hold misconceptions about the immune system, while little is known about how they reason about the mechanism by which the immune system operates. This study adopted a qualitative approach to identify students' reasoning about the immune system in Grade 8 and how reasoning developed for the same students in Grade 12 in Beirut, Lebanon. Participants included 46 Grade 8 students and we followed 16 of them through Grade 12 while studying an immunology unit. Data analysis included Grade 12 students' responses during a pre-/post-assessment test and post-unit interviews. In Grade 8, data analysis comprised a pre/post-unit multiple-choice immunology exam and written responses on classroom activities. In addition to the previously determined five reasoning levels for Grade 12, we identified two extra lower levels for Grade 8 students. These levels included explaining causal relations between events without recognizing any mechanism and identifying a process using incorrect scientific terms. We also tracked one student's reasoning and showed a persistent misconception of the role of antibodies and difficulty in linking the specific to non-specific immune responses. We discuss those results by identifying the problem in reaching high levels and suggesting implications for curriculum and instructions.

Accessing Quantum Mechanics in the Secondary Classroom

Zac Patterson*, The Ohio State University, USA
Lin Ding, The Ohio State University, USA

ABSTRACT
Contemporary physics topics such as quantum mechanics have increasingly found a place in secondary science curricula in recent years. Topics that were once the sole privilege of university physics majors are now highly accessible through a plethora of open-source digital resources and a commitment to concept-based instruction by the science education community. Now more than ever K-12 students can gain exposure to the most intriguing and bizarre components of the physical universe in formal learning settings. Exploring the quantum realm has shown to deeply engage students and the applications of quantum technologies are becoming increasingly relevant to the lives of everyday citizens. While exposure to these interesting topics at the secondary level is increasing it is still an understudied area in physics education research. In this paper we present a literature review of the current body of research addressing the teaching and learning of quantum mechanics at the secondary level and then propose theory-based suggestions for pedagogical strategies.

Computer Studies Made Easy: Improving Students Achievement through the Culturo-Techno-Contextual Approach

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Esther Peter, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
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Fred Awaah, University of Professional Studies, Ghana

ABSTRACT
Following unabated poor performance of students in terms of achievement despite the efforts of science educators, we have continued to sort for the better way of delivering the lessons. This study examined the potency of Culturo-Techno-Contextual Approach (CTCA) on achievement of students in networking. This study employed a mixed-method design (quasi-experimental and interviews). This study involved students from two public senior secondary schools (SS2) in Lagos state, Nigeria with a total number of 172 students. The control group who were taught with lecture method had 73 students (58 males/15 females) while the experimental group that were taught with CTCA had 99 students (52 males/47 females). Both groups had a pretest and a posttest using the Achievement Test in networking (reliability 0.70) and Networking Attitude Questionnaire (reliability 0.94), after which interviews were conducted to gather data for the qualitative phase. Data gathered were analyzed using one - way ANCOVA as intact classes were used. The results obtained from the one - way ANCOVA statistics revealed a statistically significant difference in the method of teaching. This means that the experimental group (CTCA) performed better than the control group (lecture method). Implications for the study were highlighted.

Examining Student Perceptions of Accountable Disciplinary Knowledge in their Science Class versus Data Jam

Isabel Delgado*, The Learning Partnership, USA
Steven McGee*, The Learning Partnership, USA

ABSTRACT
This paper discusses middle and high school students' perceptions of Accountable Disciplinary Knowledge in their science class versus Data Jam research experience in public and private schools in Puerto Rico. The Data Jam model provides a unique opportunity for students to engage in independent data analysis research projects using ecological data. This paper is part of a larger study about implementation of the Luquillo Data Jam program. Our collective qualitative case study (Creswell, 2012; Merriam & Tisdell, 2016; Stake, 2010) examined student interview transcripts and content analysis of Data Jam posters to determine similarities and differences between what students are held accountable to in the typical

science classwork and what is expected in the research experience in Data Jam. Our findings reflect that students participating in Data Jam experienced a disconnect between what they perceived as Accountable Disciplinary Knowledge in their science class versus what they perceive as Accountable Disciplinary Knowledge in Data Jam. This highlights the importance of integrating wide variety of experiences in which the Accountable Disciplinary Knowledge is compatible with the practices of science.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Impact of Interactions on Learning Science
4/19/23, 16:30-18:00, Blvd C (L2)

Positioning in small groups around a Black Woman and equipment handling in physics lab
Mark Akubo*, Cornell University, USA
Emily Stump, Cornell University, USA
Natasha Holmes, Cornell University, USA

ABSTRACT
In undergraduate physics laboratory courses, there is new emphasis on engaging students in authentic science learning experiences centering on knowledge-building. Limited research, however, has sufficiently explored the ranges of positioning dynamics around equipment handling roles, particularly in gender and racially diverse groups. This is especially true for the experiences of women of color. We seek to identify and describe the dynamics of students' positioning around equipment handling in multiple diverse groups that included a Black Woman who indicated preference towards handling the lab equipment. We draw on literature on positioning theory, discourse analysis, roles, small groups, and physics labs to analyze episodes of video on the groups. We characterize each group's dynamics, identified participants' roles around equipment handling, and wrote memos on the positioning dynamics. We find that students enacted three positioning dynamics in the groups: explicit assignment, implicit assignment, and explicit negotiation. Also, different positioning dynamics and distinct types of interactions across groups shaped the Black woman's participation around the equipment handling role. The complexities in interactions and positioning dynamics across groups increase the weight of evidence that suggests explicit role assignment in small groups does not guarantee group work equity.

How positioning affects students' engineering experience during small group engineering design activities
Minyoung Gil*, Penn State University, USA
Gregory Kelly, Penn State University, USA
Matthew Johnson, Penn State University, USA

ABSTRACT
As engineering design is increasingly being applied to elementary school classes and the issue of equity has also continued to receive attention, it is crucial to examine whether elementary school students have equitable opportunities in small group engineering activities. This study

aims to investigate how students' positioning appears in engineering small group activities and how positioning connects to their engineering experience. Two groups were selected from two fourth-grade elementary school classrooms, and discourse analysis was conducted on engineering design activities that create filters to catch plastics. To this end, eventmaps, transcripts, and positioning maps were created based on video data. Findings suggest that students' positioning was dynamic and interactive, and they partially used epistemic practices of engineering. However, as students in leadership positions dominated the activity, other students' suggestions were rejected, or opportunities to participate in the activity were lost. This also resulted in some students with passive positions losing confidence in their designs or eventually losing interest in engineering activities. The results of this study suggest that teachers and teacher educators need to think about how small group engineering activities affect students' engineering experiences and devise ways to support students' equitable participation and learning opportunities.

Noticing Beyond Disciplinary Ideas Prompts Re-imagination of Classroom Interactions that Foreground Students' Classroom Experience

Laura Blue*, Dublin City Schools, USA
Sophia Jeong*, The Ohio State University, USA
Ashlyn Pierson, The Ohio State University, USA

ABSTRACT
Teacher noticing studies typically focus on attending to student disciplinary ideas. However, important teacher learning also takes place related to other aspects of teaching/learning, such as discourse moves to equitably distribute participation, and strategies to cultivate a sense of community within the classroom. This study used an expanded notion of the Attend-Interpret-Respond framework as a methodological tool to determine what teacher candidates noticed beyond student disciplinary ideas during video club built into science methods coursework. Findings illustrated three themes of teacher candidate noticing which informed reflections. These included: talk moves, teacher persona, and classroom management strategies. Noticing events along these themes triggered reflections that centered on provisions of context, rationales/reasons behind teacher actions, and re-imagined alternative approaches that weighed their potential impact on students' experiences. Bandura's Social Cognitive Theory provided a lens to consider the findings and to deepen understanding of the types of teacher learning that resulted from video club. Broadly, video club supported teacher learning through the observation of others and in the provision of space to re-imagine teacher actions as an act of forethought to guide future decisions to support equitable and inclusive teaching.

Strand 4: Science Teaching - Middle and High School (Grades 5-12): Characteristics and Strategies
SC-Organized Paper Set: Student Engagement, Epistemology, and Socioscientific Approaches
4/19/23, 16:30-18:00, PDR 2 (L3)

Concurrent Session 6, 4/19/23, 16:40-18:00

Stimulating Students' Socio-Scientific Perspective Taking through Personas

Dury Bayram Jacobs*, Eindhoven University of Technology, Netherlands
Ineke Henze, Radboud University, Netherlands
Erik Barendsen, Radboud University, Netherlands

ABSTRACT
This study investigates students' conception and the influence of the use of personas on the learning outcomes with respect to perspective-taking and argumentation in informed decision-making. In this exploratory study, students' conception of perspectives in terms of personas and arguments is investigated. 40 students participated in this study and were asked to create two personas according to their own ideas without any requirements or limitations. For each persona, they provided two possible arguments in favor and two possible arguments against the statement. Finally, the students weighed the arguments for each persona to reach a conclusion about the overall opinion of the persona. Students' assignments booklets, including persona descriptions, arguments and opinions were collected. Data were analyzed qualitatively. The students developed a variety of personas, both with professions and backgrounds in science and with non-science contexts. The perspectives of the most frequent arguments (scientific, technological, and economic) are the same for both groups and arguments have similar themes. It is surprising that, in contrast, the overall opinion (after weighing the respective arguments) does show a difference between ‘scientists' and ‘non-scientists'. We conclude that the persona approach stimulated students' perspective-taking however, the persona construction process can be scaffolded more explicitly.

"Creative vibes:" Using a comic in science curriculum and teaching to promote student engagement

Consuelo Morales*, Michigan State University, USA
Tania Jarosewich, Censeo Group, USA
Hildah Makori*, Michigan State University, USA
Maria Salinas, Michigan State University, USA
Irene Bayer, Michigan State University, USA

ABSTRACT
Engaging curriculum that invites all students to learn science has long been a goal in science education, and gets at the heart of equity in science learning. Comics that have accurate science content, interactive features, and characters with whom students can relate could offer students accessible and interesting learning materials. Our project studied a comic embedded in a high-school biology curriculum to answer the questions: What are students' and teachers' perceptions of an embedded comic? How did teachers use the comic in instruction? How did students engage with the comic? This mixed-method study found student engagement at behavioral, emotional, cognitive and agentic levels (Sintara, 2015). Students actively participated in learning by exploring the comic, generating robust classroom discussion around science and issues related to race and racism in science. Teachers, and the majority of surveyed students, agreed that the comic helped them to learn the science in the unit and to better understand the role of field research. The synergy between the embedded comic and curriculum provides a model for curriculum creation and use. The study engenders additional

research questions in science education, including literacy in content learning, connecting to careers in STEM, and measuring science learning through a comic.

Designing and Enacting Lessons to Promote Students' Epistemic Agency in a Middle School Biology Classroom

Ozlem Akcil-Okan*, Florida State University, USA
Miray Tekkumru-Kisa, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT
Reform-based instruction that fosters all students' intellectual engagement and sensemaking is possible. However, it is not yet prevalent across many science classrooms. To gain more insight into how to design and enact science instruction supporting students' intellectual engagement, this investigation centered on understanding how to design and implement science lessons for promoting students' intellectual engagement as epistemic agents who shape knowledge building happening in the classroom. We examined a middle school science teacher's design and implementation of four lessons that she did as part of a PD focused on fostering productive science talk in science classrooms. Our analysis revealed that her efforts in fostering opportunities for students' epistemic agency were evident in both her lesson design and implementation. Her responsiveness to students' thinking/intellectual engagement throughout the lesson implementations by using principled improvisations supported opportunities for students' epistemic agency. Her efforts allow us to understand how the design and implementation of science lessons with the focus on opening space and maintaining this space by being responsive to students' thinking are critical for fostering students' epistemic agency. These findings can provide implications for professional development efforts that seek to develop teachers' capacity for reform-based instruction in science classrooms.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Student Development of Research Skills
4/19/23, 16:30-18:00, Salon C7-8 (LL)

Research Deconstruction: A Scalable Model for Promoting Scientific Literacy Skills in Introductory Biology Classes

Casey Shapiro*, UCLA, USA
Brit Toven-Lindsey*, UCLA, USA
Marc Levis-Fitzgerald*, UCLA, USA
Ira Clark, UCLA, USA

ABSTRACT
Research deconstruction (RD) is a pedagogical strategy used to promote scientific practices and increase science engagement. This approach introduces students to scientific research by "deconstructing" a research seminar led by a faculty speaker over several class sessions. This

strategy has been shown to increase students' scientific research skills. To test the scalability and utility of this intervention, this study investigates a partnership between 4-year and 2-year colleges that deployed RD modules into existing introductory biology courses. Using data from instructor interviews coupled with matched pre-post survey responses and course assignments from enrolled students, we share faculty experiences and lessons learned from implementing a RD module into their course. Faculty interview data highlighted the benefits of RD for both the instructor and students, including opportunities to broaden access to research within the context of limited institutional resources and flexibility to implement the RD module within an existing course structure. Data from faculty interviews and student surveys indicated the RD module enhanced students' understanding of scientific research, increased their scientific literacy skills, and helped them see how science connects to real-world problems.

Understanding how a college instructor led science majors to write using a situated learning perspective

Austin Heil*, University of Georgia, USA
Julie Kittleson, University of Georgia, USA

ABSTRACT
College science majors struggle with scientific research writing (i.e., journal articles) when entering graduate school and their post-graduation careers. One reason for students' struggle is the paucity of disciplinary writing instruction during their undergraduate curriculum. Our research qualitatively explored a novel undergraduate Scientific Research Writing course to discover how the instructor of this course supported student learning. Using a situated learning perspective, we conducted semi-structured interviews, classroom observations, and informal interviews with the instructor to answer two research questions: 1) in what ways does the instructor describe supporting student learning of scientific research writing? and 2) what challenges were associated with the instruction of scientific research writing? Our abductive analysis uncovered the instructor negotiated their role as a knowledgeable other, three dimensions that characterized the instructor's approach to teaching scientific research writing, and four challenges the instructor encountered. We discuss practical and theoretical implications for the teaching and learning of scientific writing in higher education.

College Student Conceptions of Experimental Design and Argumentation in the Earth Sciences

Danielle Ford*, University of Delaware, USA
Christy Metzger*, University of Delaware, USA

ABSTRACT
This study examines the scientific thinking of 95 undergraduates, primarily future elementary teachers, enrolled in a large active-learning Earth Science course for nonmajors. Students, who had exposure to place-based, active-learning content aligned with the Next Generation Science Standards, responded to questions aligned to the three dimensions of the Next Generation Science Standards. We report on their conceptions related to the SEPs of Planning and Carrying Out Investigations (SEP3), Engaging in Arguments from Evidence (SEP7), and Analyzing and Interpreting Data (SEP4); and DCIs and CCCs related to the Earth Science of natural hazards, climate, models, and spatial thinking. A qualitative analysis of open-ended

question responses indicate that students interpret graphs and cite prior content knowledge to evaluate scientific claims, but attend to superficial, rather than discipline-specific characteristics, and do not consistently integrate their understandings of Earth Science content and practice. They also conceptualize experimental designs through their future teacher lenses, proposing that Earth Science questions be answered through real-time, small-scale studies in the field or laboratory rather than through historical or large data set modeling. Implications for nonmajor science course design and teacher education programs are discussed.

Critical Thinking: Perceptions and Experiences of Science and Engineering Instructors and Students

Carmella Shahab, The Technion Israel Institute of Technology, Israel
Miriam Barak*, The Technion Israel Institute of Technology, Israel

ABSTRACT
Critical thinking (CT) is viewed as a core competency essential for university graduates to successfully compete in the 21st century global economy. However, much obscurity remains regarding its practical role or how to integrate it in science and engineering education, especially in an era of digital teaching and learning. Moreover, studies on CT overlook globalization trends such as student mobility, where international students are a significant portion of the student body. Therefore, the goal of this study was to examine the way CT is conceptualized and experienced by instructors, local students, and international students in a science and engineering university; and accordingly, design a culturally-inclusive theoretical framework for CT cultivation in the digital era. The study applied an integrated dual-analytic approach, where data was collected via a survey and semi-structured interviews. The findings show that many instructors and students lack a comprehensive understanding of CT skills. The findings also show that the international students were more familiar with CT in theory and practice than the local students, with ‘analysis' as one of the prominent skills experienced in academic courses. The study presents examples of digital activities that can be incorporated in a CT instructional framework.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Understanding the use of models and representations in science learning
4/19/23, 16:30-18:00, Salon A2 (LL)

Exploring Elementary Preservice Teachers' Use of Drawings to Reason about Force-Related Phenomena

Teresa Leavens*, College of Education, North Carolina State University, USA
James Minogue, College of Education, North Carolina State University, USA

ABSTRACT
This mixed methods study explored learning outcomes of elementary preservice teachers (PST) in a science methods course incorporating explicit instruction on drawing to reason.

Drawing instruction was guided by Quillin and Thomas' (2015) framework with instruction dimensions addressing affect, visual literacy, and model-based reasoning. Primary data included a series of PST-generated drawings and end-of-course semi-structured interviews. Drawing and interviews were analyzed for learning outcomes based on aspects of modeling competency, including use of multiple models, nature and purpose of models, and model changes (Belzen et al., 2019). The explicit instruction on drawing to reason about a force-related phenomenon resulted in increased use of different types of model translations, including visual to text, vertical between scales, and horizontally within the same scale. PSTs also progressed from viewing the purpose of drawing as an illustration or record of observations to an evolving explanation of their understanding of the phenomenon. The iterative cycle of drawing supported inclusion of new knowledge and recognition of uncertainties in PSTs' explanations. This study has implications for expanding PSTs' science teaching knowledge of instructional strategies such as drawing for supporting quality science learning in the elementary classroom.

Supporting Pre-Service Science Teachers in Designing and Reflecting on Coherent Instruction

Stefan Sorge*, IPN - Leibniz-Institute for Science and Mathematics Education, Germany
Dustin Schiering, IPN - Leibniz-Institute for Science and Mathematics Education, Germany
Mathias Ropohl, University of Duisburg-Essen, Germany
Christopher Like, University of Iowa, USA
Jeffrey Nordine, University of Iowa, USA

ABSTRACT
Science instruction can be characterized as very content focused and often times fragmented. One way to change this type of instruction is through a focus on coherence in instruction. Yet, research points out that providing coherence-oriented curriculum materials to teachers is not sufficient to change the type of instruction. Instead, it is necessary to support pre-service teachers in bridging the research-practice gap through purposefully designed learning activities in teacher education. These learning activities should be centered around a common conceptual understanding (i.e., coherent science instruction) and applicable throughout multiple learning settings. Therefore, we followed a design-based research approach to develop and adapt a set of planning and reflection tools centered around the idea of coherent science instruction. To investigate the assumptions of our design, we conducted semi-structured interviews with nine pre-service teachers after the introduction of those tools. Following an inductive coding approach, we were able to identify five themes that included ideas of cohesion, sequencing, learning goals, phenomena, and students' sense-making. These themes were most prominently mentioned in conjunction with a storyline planning tool highlighting its potential to support pre-service science teachers in planning coherent science instruction. Additional design features for planning/reflection tools are discussed as well.

Analysis of Pre-Service Teachers' Choices of Multiple Visual Representations for Teaching about the Cardiovascular System

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

Eunice Nyamupangedengu, Marang Centre for Mathematics and Science Education, School of Education, Wits University, South Africa

ABSTRACT
In biology education the content tackles the conceptual and linguistic difficulties of learning biology at each level—macro, micro, sub-micro, and symbolic, suggested by Treagust and Tsui (2013), where choice of representations play significant role in teaching across these levels and in various combinations, as well as in differing contexts and topic areas. In this study, we investigated twelve practicing & pre-service teachers' choices of representations for teaching the cardiovascular system. CoRes prompts and semi-structured interviews were used for data collection as described above. From the ten participants' responses it is revealed that nine participants were unsuccessful in choosing appropriate representations for selected key concepts/big ideas. The results show that participants had misunderstanding choices of representations in terms of cardiovascular system. This study suggested certain constraints related to productive visual representations in school science learning and instruction such as, need to promote critical awareness of representations among PSTs, teacher educators, instructional designers and policy makers, which if not appropriately designed and implemented will create student difficulties and misconceptions.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: The role of Creativity, Computational & Design Thinking in pre-service teacher learning
4/19/23, 16:30-18:00, Salon C1-2 (LL)

Using artificial intelligence (AI) to foster preservice teachers' understandings of computational thinking (CT) and AI

Jeffrey Radloff*, SUNY Cortland, USA
Ibrahim Yeter, National Institute of Education (NIE), Singapore, Singapore
Gregorio Robles, University of Madrid, Spain

ABSTRACT
Recent STEM reform promotes integrating computer science (CS), meaning teachers need understandings about real-world CS applications such as artificial intelligence, or "AI". Yet, little is known about how preservice teachers perceive AI or how these perceptions change after engaging with it within a STEM classroom setting. This study employed survey methods to explore elementary PSTs' perceptions about AI before and after a series of lessons about AI. Participants were PSTs enrolled in STEM pedagogy courses (n = 63) at a small northeast teaching college. Findings revealed PSTs held diverse views of AI and felt polarized about its usage before and after the lessons; gained CT understandings. Most viewed AI as beneficial, while others focused on negative impacts and stigmas. Findings suggest the need for resources that address AI misconceptions and allow PSTs to examine related beliefs.

Concurrent Session 6, 4/19/23, 16:40-18:00

Design Thinking for Human-Centered Engineering: Preservice Teachers' Engineering Design Projects for Underserved Communities

Myunghwan Shin*, California State University, Fresno, USA
Jane Lee, Michigan State University, USA

ABSTRACT
Engineering design has earned increased attention in science teacher education. Despite the increased significance of engineering design, recent studies unveiled that engineering design represented in K–12 schools is overly focused on its technical aspects rather than the social, cultural, or human aspects of engineering. This study aims to explore how preservice elementary teachers reimagine teaching engineering design by embracing design thinking, a human-centered problem-solving approach, in a STEM education course offered by a US teacher education program. Grounded in the framework of design thinking and ethnographic research methods, we investigated how preservice elementary teachers participated in engineering design projects for underserved communities guided by design thinking and what lessons they learned from the approach. We present three key themes that emerged from our data: 1) engineering with empathy reveals new insights; 2) caring for people promotes expanded learning; and 3) creative confidence in engineering. The findings suggest that adopting design thinking creates a new space where preservice teachers learn how to weigh up, negotiate, or coordinate multiple aspects of engineering design and engage in more authentic, collaborative, and human-centered engineering grounded in empathy and care.

Supporting Preservice Teachers to Conceptualize Computational Thinking as a Sensemaking Practice in an Engineering Course

Gozde Tosun*, Penn State University, USA
Amy Farris, Penn State University, USA

ABSTRACT
Everyday knowledge-producing practices in sciences and engineering draw heavily on computational practices. While scholars have long argued that science learning is reflexive (Harel & Papert, 1990) with computing, in the U.S. and many other countries, computational thinking (CT) now appears in science standards and other policy documents. This prominence, especially in light of the confusion about CT's role (Authors, 2022) in scientific sensemaking and engineering design, presents an important challenge for teacher preparation. This proposal presents a qualitative exploratory study in which we aim to support pre-service teachers' (PSTs) learning of CT in the contexts of science learning and engineering design. We draw on data from the Spring 2022 engineering content course. Throughout the semester, PSTs explored scientific concepts and solved engineering design problems through engaging in epistemic engineering practices (Cunningham & Kelly, 2017). Despite wide agreement that computation serves as an epistemic practice in engineering (Chandrasekharan & Nersessian, 2017), supporting PSTs' understanding of CT as sensemaking practices in engineering design remains under research. Our paper presents preliminary findings that illustrate howlearning about CT in elementary science/engineering became reflexive with PSTs' own undergraduate-level experiences in engineering design when they continuously reflected on the CT practices evident in their work.

Fostering Preservice Teachers' Creativity and Innovation Through 3D Printing: Individual and Group Outcomes

Shannon Navy*, Kent State University, USA
Elena Novak, Kent State University, USA
Ilker Soyturk, Kent State University, USA

ABSTRACT

Although it is known that 3D printing can integrate science, technology, engineering, and mathematics in K-12 classrooms, little is known about how 3D printing also fosters important 21st century skills, such as creativity. To increase the knowledge in this area, this paper focuses on the effects of 3D printing on preservice teachers' creativity and innovation. It also compares the effects of creativity and innovation for those who worked individually and those who worked in groups. The participants were 58 early childhood education preservice teachers enrolled in a science methods course in the United States. The science methods course integrated a 3D printing experience across the semester. The quantitative data for this study included measures for innovation and creativity. Results revealed the 3D printing project improved the preservice teachers' innovation. There were no differences in innovation outcomes for students who completed the project individually compared to students who completed the project in groups. However, there were differences in creativity scores for final products. Students who completed the project individually had higher creativity scores than those who worked in groups, particularly in the novelty dimension of creativity. This study highlights the positive outcomes of an embedded 3D printing experience for preservice teachers.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Professional Learning Communities Supporting Science Teacher Learning
4/19/23, 16:30-18:00, Salon A1 (LL)

Understanding science teacher perceptions of the influence of vertically and horizontally aligned collaborative teams

Sharfun Islam Nancy*, University of South Florida, USA
Karl Jung*, Bradley University, USA
David Rosengrant, University of South Florida, USA
Allan Feldman, University of South Florida, USA

ABSTRACT

There is a nationwide need for science teachers who are highly qualified to address the needs of students' science learning and it is important that teachers are equipped with skills to adapt to the varying needs of the current trends in science education. Many teachers still struggle to integrate novel science instruction that aligns with recent benchmarks and standards such as NGSS. Through professional development, learning and teaching science with colleagues in a

socially collaborative context can be an opportunity to address this need to develop skilled science teachers. The collaborative coaching and learning science (CCLS) structure is one such model that unites collaborative coaching and learning through professional development among teachers. This study examines a two-year professional development program utilizing the CCLS structure with K-12 science teachers and explores how teachers perceived two different CCLS structures in terms of developing their instructional practice and science content knowledge. Findings demonstrate which aspects of the program they perceived most beneficial for supporting their science teaching and content understanding. Implications for two types of CCLS models and their impact on science teaching and learning for K-12 teachers will be discussed.

The Value of Participation in Professional Learning Communities (PLCs) for High-School Chemistry Teachers

Anat Shauly*, Technion - Israel institute of technology, Israel
Shirly Avargil, Technion - Israel institute of technology, Israel

ABSTRACT

Professional Learning Communities (PLCs), where teachers meet regularly for discussions and collective learning, are a rising platform for teachers' professional development and their contributions are of interest. This study examined PLC participation using the Value Creation Framework developed by Wenger et al. (2011), which defines five value cycles: Immediate, Potential, Applied, Realized, and Reframed. We asked from the participants' perspective: As a result of participating in the PLC network, what value was gained and how it was described? The research setting was PLCs of Hebrew- and Arabic-speaking chemistry teachers with varying experience levels. Thematic analysis of nine reflections focused on value cycles. Developing social relationships was the PLC's key contribution. Three important value cycles were identified. Productive and encouraging interactions among teachers demonstrated Immediate value. Potential value was in planning future lessons. Realized value cycle included performance improvement due to members' support, feedback, knowledge sharing, and reflection within diverse communities.
The theoretical contribution was the discussion of collaborative learning using CoPs and PLCs as frameworks. Using the Value Creation Framework showed how social learning benefits teachers' classrooms. Practically, leaders should spend more time on group reflection and discussions. Reflection should be part of the evaluation process, both individually and collectively.

Navigating Tensions Between Social Justice Theory and Practice in a Chemistry Education Professional Learning Community

Kathryn Ribay*, San Jose State University, USA

ABSTRACT

Maintaining a commitment to social justice teaching can be especially challenging when navigating the bureaucratic systems and ever-spiraling responsibilities of the education system. To better understand how social-justice-oriented educators navigate these tensions, this paper uses qualitative methods to investigate the social justice problems of practice

identified by five chemistry teachers in a year-long professional learning community. By analyzing the challenges described in their problem-posing segments, I identify seven major themes that represent key sources of tension and possibility as teachers moved from theory to practice in teaching chemistry for social justice. These findings indicate that the practical considerations of day-to-day teaching practice create especially salient tensions when moving from theoretical ideas of social justice to enactment of social justice teaching. Through a deeper analysis of two cases, I demonstrate the effects of discussing problems of practice with a group of teachers who had similar disciplinary backgrounds and ideological stances. These discussions shifted the tensions from potential barriers to areas of possibility in which they were able to enact new ideas within the confines of their context. Taken together, these findings indicate that developing social justice educators requires attention to navigating the practical details of teaching from a social justice lens.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Personal Dynamics of Learning for Elementary Science Teachers
4/19/23, 16:30-18:00, Salon C3-4 (LL)

Now I'm a Science Teacher: Shifting Professional Identities of Elementary Teachers in Long-Term PD

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
Christine Lee Bae, Virginia Commonwealth University, USA

ABSTRACT
The purpose of this study is to better understand how the varied experiences of elementary teachers in long-term science PD lead to shifts in teachers' professional identities. In this multiple case study, the Interconnected Model of Professional Growth in an Organizational Context (Authors 2016, 2019) helps explain the complex, non-linear processes that occur as teachers make sense of new information, internalize new pedagogies, and enact instructional reforms in light of student learning (Allen & Penuel, 2015; Coburn, 2004). As teachers implement reform-based instructional practices, they encounter dilemmas when the multiple identities they hold come into conflict (Enyedy et al., 2006). The Dynamic Systems Model of Role Identity (DSMRI; Kaplan & Gardner, 2017; Hathcock et al., 2020) defines the elements of identity. The intersection of the two models – PGOC and DSMRI – helps us understand how teachers' alignment with reform practices can support, or hinder, changing beliefs and goals, self-perceptions, and possibilities for action (Kaplan & Garner, 2017). This case study suggests that teachers who align with, and more substantively take up, reform-based pedagogies may be better able to manage professional identity dilemmas, manage solutions, improve their self-efficacy, and, ultimately, come to perceive themselves as science teachers in the elementary context.

Toward a Future Science Teacher: Using Teaching Debriefs to Support 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 findings are insightful and offer a significant contribution to the limited research detailing support for in-service elementary science teachers.

Agency of In-Service Elementary Science Teachers During a Global Pandemic

Anica Miller-Rushing*, University of Maine, USA
Christine Goonan, In-service teacher, USA

ABSTRACT
In-service teachers of science work with unique content and pedagogical experiences. Understanding teacher agency in these circumstances will help researchers understand the actions that these teachers take, actions that are consequential for establishing the scientific practices of students. The purpose of this study was to understand how the agency of elementary (K-5) in-service teachers was expressed discursively during a global pandemic. I qualitatively analyzed six teachers' agency through a case study approach using an interactional sociolinguistic lens. I identified the ways in which science teaching is afforded and constrained through the consequential saying, being, and doing (Gee, 2010) of teacher agency within elementary classrooms during an educational disruption caused by Covid-19. I found that elementary science teachers conceptualize and operationalize their agency in service to the student, thus, deprioritizing their own needs as teaching professionals. I also found that centering the teacher voice during the research process increased teachers' reflexivity about their professional agency. Recommendations are addressed.

Concurrent Session 6, 4/19/23, 16:40-18:00

Strand 10: Curriculum and Assessment
SC-Organized Paper Set: Curricular innovations supporting new age learning outcomes
4/19/23, 16:30-18:00, Salon C5-6 (LL)

Investigating the impact of a STEAM program on group scientific creativity

Hye-Eun Chu*, Macquarie University University, Australia
Ei-Seul Kim, Seoul National University, Korea, Republic of
Hyong-Moon Lee, Seoul National University, Korea, Republic of
Sonya Martin, Seoul National University, Korea, Republic of

ABSTRACT

The aim of this paper is to report on the impact of a STEAM program on group scientific creativity. STEAM refers to an approach to teaching STEM subjects that integrates an arts or cultural dimension into the STEM subject's teaching/learning activities. In this paper group scientific creativity is defined as a construct comprising divergent thinking, convergent thinking, synthesis, analytic thinking, the application of knowledge in new situations, and problem-finding/- solving. A STEAM program of lessons was implemented at a school in Korea and at another school in Australia. Data on scientific creativity were collected by means of a questionnaire administered before the start of the program and after its conclusion, and post-program interviews with 10 students selected from the program participants. The results revealed significant positive changes in indications of group scientific creativity after the four-week STEAM program. We conclude that the effect of encouraging group scientific creativity was attributable to three reasons: 1) engagement in solving a real-world problem, 2) collaborating in a small group, 3) experience of non-familiar cultural perspectives.

Remote-Accessible Quantum Photonics Lab for Improving Learning Outcomes

Sahil Patel*, University of California, Santa Barbara, USA
Max Shen, University of California, Santa Barbara, USA
Quynh Dang, University of California, Irvine, USA
Galan Moody, University of California, Santa Barbara, USA

ABSTRACT

The recent emergence of technologies based on quantum information science have led to a demand for increased quantum education for the workforce as outlined by the National Quantum Initiative Act. Industrial implementations of quantum technologies require hands-on skills on state-of-the-art equipment and a deep understanding of how quantum mechanics concepts are leveraged by technologies. Traditional courses on quantum mechanics are abstract and provide minimal teaching of physical implementations of quantum concepts. We aim to address this gap between industry-required skills and traditionally taught skills by delivering a hands-on learning approach that reinforces key concepts and teaches students industry-transferable skills. Our experiment-based lab course is fully automated, remotely accessible, and consists of six lab modules that each focus on different key concepts in QIS. In its inaugural implementation, the course has shown to increase student learning in all selected

topics of QIS, allowing conclusions to be drawn on effective learning strategies. In addition, the remote access and automation may be used to expand the reach of our learning modules to diverse communities and is a step towards removing the barriers of cost and expertise in the quantum education learning space.

Implementing engineering aspects in chemistry lessons using a nanoscience student lab

Tim Goebel*, University of Kassel, Germany
David-S. Di Fuccia, University of Kassel, Germany

ABSTRACT
Research shows show that students often fail to recognize the relevance of scientific knowledge (BARKE ET AL., 2015). In addition, engineering science issues that would show the usefulness of scientific knowledge, are hardly found as subjects of teaching in general schools in Germany. The aim of our work is therefore to link the engineering and natural sciences by merging the process of technical development with the path of knowledge acquisition in natural science. The link between the two sciences is desirable, as it - in the sense of contextualizing scientific knowledge - could increase the students' motivation and interest in technical and scientific issues (PARCHMANN & RALLE, 2016). Moreover, in this way the learners could better understand the fundamental process from basic research to the finished technical application. In the English-speaking world, first concepts have been developed that show a positive effect in this merger, but a corresponding ad-aptation is still lacking for Germany (SNEIDER, 2015). In our approach, the pupils are to be offered insights into both methodologies and contentrelated aspects of current technical and scientific research in the field of "nanostructures" in a prepared learning environment, containing an atomic force microscope.

Strand 11: Cultural, Social, and Gender Issues
Symposium: Justice Centered Ambitious Science Teaching (JuST): Ways Core Practices Can Center Justice
4/19/23, 16:30-18:00, Salon A3 (LL)

Symposium: Justice Centered Ambitious Science Teaching (JuST): Ways Core Practices Can Center Justice

April Luehmann*, University of Rochester, USA
Todd Campbell, University of Connecticut, USA
Yang Zhang, University of Rochester, USA
Dé Scipio, University of Washington, USA
Priya Pugh, University of Washington, USA
Kyle Sullivan, University of Rochester, USA
Hannah Cooke, University of Connecticut, USA
Gena Merliss, University of Rochester, USA
Jessica Thompson, University of Washingon, USA
Veronica Cassone McGowan, University of Washington Bothell, USA

Lenora Crabtree, University of North Carolina, USA
Angela Calabrese Barton, University of Michigan, USA
Day Greenberg, Indiana University, USA
Scott McDonald, Pennsylvania State University, USA
Jonathan Mccausland, New Mexico Highlands University, USA
Jennifer Jackson, Pennsylvania State University, USA
Hosun Kang, University of California Irvine, USA
Heather Clark

ABSTRACT
Although the Ambitious Science Teaching (AST) framework was designed to promote deep learning for all students (e.g., Authors, 2018), scholars argue whether or not this framework is adequate for centering social justice in teaching (e.g., Authors, 2019). Conversations are needed to explore if and how core practices such as the AST framework (Authors, 2012) can be shaped for justice-centered teaching (e.g., Authors, 2021) and teacher learning. Though "equity and "social justice" have captured our nation's awareness as well as scholars' and practitioners' commitments, the meanings of these concepts lack agreement. Importantly, Author and Author's (2016) four equity discourses frame "equity" in ways that include but move beyond promoting the "access paradigm" of mere inclusion. There is an urgency to support science teaching that aims for more than test preparation and represents transformed goals, norms, practices, representations, and purposes to break free from its hegemonic historical foundations. In this structured poster session, scholars engaged in teacher development promoting justice-centered ambitious pedagogy share their findings to support our NARST community in navigating the tensions and possibilities involved in enacting equitable science education.

Presentation titles

Justice-centered Ambitious Teaching: Exploring Teachers' Experiences with a JuST Culture-Setting Unit

Can Learning Stoichiometry Matter?

Designing for Collective Futures: The Engineering for Ecological and Social Justice Framework in Preservice Teacher Education

How did we get here? Selecting Justice-oriented phenomena to support the Sociopolitical Turn

Constellations of Core Equitable Practices in Informal STEM Learning (ISL) Institutions

Nurturing Preservice Teachers' Professional Identity as Justice-Centered Ambitious Science Teaching Practitioner

Anti-Racist Ambitious Science Teaching as an Organizational Structure to Support Preservice Teacher Learning Developing a Justice-Centered Teacher Identity in Professional Learning Communities

Concurrent Session 6, 4/19/23, 16:40-18:00

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set: NOS and Decision-Making
4/19/23, 16:30-18:00, Waldorf (L3)

The Impact of Understanding Nature of Scientific Knowledge and Scientific Inquiry on Learning about Evolution

Juan Jimenez*, University of Talca, Chile
Norman Lederman, Illinois Institute of Technology, USA

ABSTRACT
Nature of Scientific Knowledge (NOSK) and Nature of Scientific Inquiry (NOSI) are important components of scientific literacy and important educational objectives in science education. Recent literature theorizes that both may increase students' understanding of science content knowledge. The main purpose of this study was to empirically test that assumption and determine which NOSK and NOSI aspects are most useful in such an endeavor. Using a quasi-experimental, nonequivalent control group design, a sample of 453 9th grade high school students from 12 classes in a large city were randomly assigned to intervention and control groups via classroom clusters. Students in the intervention groups were given an online explicit and reflective five-week NOSK/NOSI Unit and an online five-week Evolution Content Unit as a treatment. To measure understanding of NOSK and NOSI and understanding about evolution, students answered three valid and reliable instruments. The results of this study showed that the NOSK/NOSI Unit was effective in improving understanding of NOSK and NOSI aspects in the intervention groups. They also outperformed the control groups by scoring higher on the Evolution Content Test. Taken together, the findings support the assumption that understanding NOSK and NOSI improves learning about evolution.

Beyond the Science: Factors that Influence University Biology Students' COVID-19 Actions and Vaccine Acceptance

Benjamin Herman*, Texas A&M University, USA
Michael Clough, Texas A&M University, USA
Asha Rao, Texas A&M University, USA
Alex Sobotka, Texas A&M University, USA
Ben Janney, Texas A&M University, USA
Alister Olson, Texas A&M University, USA
Aaron Kidd, Texas A&M University, USA
Sarah Poor, Texas A&M University, USA

ABSTRACT
Like all SSI, engaging the COVID-19 pandemic involves scientific thinking and may vary across social groups. This investigation determined how science views and sociocultural membership associated with 967 university biology students' COVID-19 vaccine acceptance and actions. Hierarchical moderated regression analyses demonstrated that higher levels of vaccine acceptance associated with students' rejection of vaccine conspiracy views, increased COVID-19 prevention knowledge, higher levels of trust in the stability and reliability of

COVID-19 science and the CDC to provide the consensus view of COVID-19 science, and holding a more liberal political ideology. Being increasingly politically conservative and believing COVID-19 misinformation significantly associated with lower levels of COVID-19 mitigating actions; and increased COVID-19 spread prevention and health impact knowledge, risk perceptions, and confidence in the CDC associated with higher levels of COVID-19 mitigating actions. Political orientation moderated the relationship between students' beliefs about the stability and reliability of COVID-19 science and their committing COVID-19 actions, with an increased trust in the stability and reliability of COVID-19 science holding an important positive association with moderate, conservative, and very conservative students' COVID-19 mitigating actions. Implications discussed include the importance for helping students analyze how sociocultural membership, personal biases and trust in science interactively influence socioscientific decision-making.

Patterns for managing potential conflict between religion and evolution among Muslim undergraduate biology students

Rahmi Aini*, Middle Tennessee State University, USA
Sara Brownell, Arizona State University, USA
M. Elizabeth Barnes, Middle Tennessee State University, USA

ABSTRACT
Evolution is foundational to biology and yet controversial among undergraduate biology students. However, no research has explored views within Muslim student populations in the United States and patterns for how they may manage potential conflict between their religion and evolution. Using a mixed-method approach, undergraduate Muslim students enrolled in 47 introductory biology classes filled out surveys of evolution acceptance, evolution understanding, and perceived conflict between their religion and evolution (n=270). Further, students explained their views on the relationship between religion and evolution (n=180). We conducted a k-means cluster analysis and qualitatively analyzed open-ended responses to examine how Muslim students manage potential conflict. We found three groups that represent the patterns of these students. First, the reconciliation group consists of 39% of students who had high evolution acceptance and low perceived conflict between their religious beliefs and evolution, 2) the conflicted group consists of 26% of students who had low evolution acceptance and high perceived conflict between their religious beliefs and evolution, and 3) the uncertain group contains 35% of students who had average scores for all variables. These results indicate that Muslim students may benefit from evolution instruction that incorporates religious cultural competence in evolution education.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set: Building pedagogical capacity in preservice teachers
4/19/23, 16:30-18:00, Blvd A (L2)

Helping Preservice Teachers Develop an Expanded Functional Scientific Literacy Using an Online Module

Sarah Voss*, Drake University, USA

Lucas Menke, Drake University, USA
Jerrid Kruse*, Drake University, USA
Colin Coulter, Drake University, USA
Isaiah Kent-Schneider, Drake University, USA

ABSTRACT
Given the importance of scientific literacy for teachers and the potential utility of SSI to engage students in an abundance of relevant knowledge domains, we sought to create an SSI learning experience to help pre-service teachers explore such domains. This study involved the development and implementation of an online module for preservice teachers that explored ideas from an expanded scientific literacy through the lens of SSI. Using a design-based research approach, we sought to understand how participating pre-service teachers made sense of a self-paced online module centered on using an SSI (electric vehicles) to explore broad aspects of scientific literacy. Furthermore, the study investigates the extent to which participants applied module learning to the outcomes they plan to promote for their future students. Recommendations for improving the specific module as well as for promoting an expanded scientific literacy will be made. Although most participants were able to grasp the ideas targeted by the module questions, most intended domains were neglected by about half of the pre-service teachers when asked about outcomes for their future students.

Using Photovoice to Prompt Preservice Science Teachers' Reasoning Skills
Conghui Liu*, Indiana University, USA
Gayle Buck, Indiana University, USA

ABSTRACT
Socioscientific issues refer to complex, open-ended social issues with scientific content and process embedded within. They are often controversial, ill-structured problems and lack clear-cut solutions. A students' reasoning skills, increasingly referred to as socioscientific reasoning, are an important consideration within socioscientific instruction. This action research study focused on enhancing undergraduate students' socioscientific reasoning through the use of photovoice. Specifically, photovoice was added to a water quality unit in a scientific inquiry course for undergraduate students. Results showed that the students demonstrated a higher level of complexity and skepticism, but lower levels of ongoing inquiry and perspective-taking through the study. The findings resulted in revisions that focused more on the social aspects of the issue and the addition of more discussion on the information that is not available regarding the issue in the activity, as well as the ways in which that information may be generated.

Indonesian Preservice Teachers and Climate Change: Awareness, Beliefs, Values, and Behaviors
Kathy Trundle*, Utah State University, USA
Rita Hagevik*, UNC-Pembroke, USA
Laura Wheeler*, Utah State University, USA
Ryan Knowles, Utah State University, USA
Sary Silvhiany, Sriwijaya University, Indonesia
Rita Rudi, Sriwijaya University, Indonesia

Concurrent Session 6, 4/19/23, 16:40-18:00

Hartono Hartono, Sriwijaya University, Indonesia
Sofendi Sofendi, Sriwijaya University, Indonesia

ABSTRACT
As an archipelagic country located in a volatile extreme weather region, Indonesia is vulnerable to climatic disasters. Increased sea level in many coastal cities has forced people to move from their homes, which has heightened the need to include climate change in the Indonesian curriculum. Unfortunately, climate change education, as an important aspect of climate change mitigation, has not been a focus of the Indonesian education system. This research examined Indonesian preservice teachers' (n=2,300) attitudes about climate change, including awareness, uncertainty beliefs, values, and behaviors. Participants were enrolled in elementary, language arts/reading, languages, mathematics, science, social studies, or other education programs. We found that elementary and language arts education majors were more likely to hold an anthropocentric view of the environment, which correlates with climate denial. This finding confirms that even if you live on an island and see the water rising you do not necessarily relate the phenomenon to climate change. The values and worldviews individuals hold influence their willingness to accept climate change and to change behaviors. Thus, it is important that elementary teachers and language arts teachers have a clearer understanding of climate change. These findings have implications for curricula, outreach, and educational materials.

Graduate Student Committee
Sponsored Session: Graduate Student Forum
4/19/23, 18:30-19:30, Salon A5 (LL)

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

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Social Event: JRST DInner
4/19/23, 18:30-19:30, Astoria (L3)
By invitation

Committee Meetings
4/20/2023 7:00-8:00

Salon A1 (LL): *Membership Committee*

Salon A2 (LL): *Elections Committee*

Salon A3 (LL): *Awards Committee*

Salon A4 (LL): *Research Committee*

Salon A5 (LL): *Publications Advisory Committee*

Salon C1-2 (LL): *Equity and Ethics Committee*

Salon C3-4 (LL): *External Policy and Relations Committee*

Salon C5-6 (LL): *International Committee*

Salon C7-8 (LL): *Graduate Student Committee Meeting*

Blvd A (L2): *Social Media, Website, and Communications Committee*

Blvd C (L2): *Program Committee*

Concurrent Session 7
4/20/23, 8:40-10:10

Equity And Ethics Committee
Sponsored Session: Basu Scholars Symposium - Presentation of the 2022 Basu Scholars
4/20/23, 8:40-10:10, Salon A5 (LL)

Basu Scholars Symposium - Presentation of the 2022 Basu Scholars

ORGANIZERS
María González-Howard, U Texas - Austin, Austin, TX, USA
Sara Salloum, University of Balmand, Lebanon, Tripoli, Al Koura, Lebanon
Regina McCurdy, Georgia Southern University, Statesboro, GA, United Kingdom

PANELISTS
Takeshia Pierre, U of Florida, Gainesville, FL, USA
Alexis Riley, Cal State U - Los Angeles, Los Angeles, CA, USA
Miguel Rodriquez, California State University Dominguez Hills, Carson, CA, USA
Tatiane Russo-Tait, U of Georgia, Athens, GA, USA
Caroline Spurgin, U California, Merced, Merced, CA, USA
Hong Tran, U of Georgia, Athens, GA, USA
Selene Willis, U of South Florida, Tampa, FL, USA
Ti'Era Worsley, U North Carolina, Greensboro, Greensboro, NC, USA
Gary Wright III, North Carolina State U, Raleigh, NC, USA

ABSTRACT
This session provides an opportunity for the 2022 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 2023 Basu Scholars are also encouraged to attend this symposium in order to understand what will be expected of them in the 2024 NARST conference. To accommodate all of the scholars (10 of the 12 2022 Basu Scholars will be presenting) and to encourage generative dialogue, this 90-minute symposium is designed as an interactive poster session. Specifically, the format of the 90-minute symposium will be as follows:

* 5 min - Introduction to the Basu Scholars Program and to the symposium
* 15 minutes - Each Basu Scholar will briefly describe their work to the whole group
* 60 minutes - Interactive poster session
* 10 min - Conclusion

Awards Committee
Sponsored Session: A Celebration of NARST Award Recipients: Distinguished Contributions to Research Award [DCRA]
4/20/23, 8:40-10:10, Waldorf (L3)

A Celebration of NARST Award Recipients: Distinguished Contributions to Research Award [DCRA]

ORGANIZERS
Amelia Gotwals, Michigan State University, East Lansing, MI, USA

PANELISTS
Dana Zeidler, University of South Florida, USA

ABSTRACT
This panel session will highlight the accomplishments and contributions of the award recipients. It will provide a platform for an extended discussion of the award recipients" scholarly contributions and how their research trajectories are framed and/or intersect with the theme of NARST 2023. The award recipients will reflect on their contributions and propose ideas for the future of science education, equity and social justice, scientific literacy, teaching and learning.
The DCRA award recipients will also propose one or two questions that frame the future direction for global research in science education.

Strand 1: Science Learning: Development of student understanding
Related Paper Set: Explanations in biology: Obstacles and opportunities for teaching and learning
4/20/23, 8:40-10:10, Salon C3-4 (LL)

Revealing reasoning patterns in students' explanations using analytic grading rubrics and cluster analysis

Moriah Ariely*, Weizmann Institute of Science, Israel
Tanya Nazaretsky, Weizmann Institute of Science, Israel
Giora Alexandron, Weizmann Institute of Science, Israel
Anat Yarden, Weizmann Institute of Science, Israel

ABSTRACT
The majority of explanations in science classrooms are causal explanations that require students to identify relevant information, infer to the unobservable world, grasp underlying causes, and subsequently establish a logical connection between these causes. Numerous studies have shown that students have many difficulties in explaining scientific phenomena. Therefore, revealing students' explanation patterns and characterizing them is essential for

supporting teachers and students in learning and assessing written explanations. We present a novel approach for assessing students' explanations, which can identify specific gaps and difficulties in their explanations. We analyzed students' explanations for two open-ended questions in biology using analytic grading rubrics and conducted a cluster analysis of the students' graded explanations. Then, we characterized the explanations based on the patterns we found. The cluster analysis revealed six explanation patterns that ranged from full and correct explanations to different degrees of partial explanations that lack causal relations, some conceptual components, or both. Our findings serve as a proof of concept that analysis tools that are based on high-quality grading rubrics, can elicit patterns that are both pedagogically meaningful and stable. This approach can be further used to provide students automatic personalized feedback, which addresses the specific gaps in their explanations.

Explanatory black boxes in the biological mechanisms

Michal Haskel-Ittah*, Department of Science Teaching, Weizmann Institute of Science institute of science, Israel
Gur Livni Alcasid, Department of Science Teaching, Weizmann Institute of Science institute of science, Israel

ABSTRACT
Due to its role in understanding science, it has been recommended that educators help students reason about mechanisms. However, research has shown that this is challenging and thus students often provide non-mechanistic explanations. These challenges are exacerbated in fields that span across multiple organizational levels, such as biology.
The intrinsic complexity in biological mechanistic explanations forces the existence of at least some explanatory gaps, also known as explanatory black boxes. While studies have focused on students' difficulties in reasoning about biological mechanisms, less attention has been directed towards students' ability to reason alongside the existence of explanatory black. In this talk, we will provide theoretical justifications, for the importance of discussing black boxes in the biology classroom in order to promote science learning by avoiding the illusion of explanatory depth and discussing uncertainty in science. Then, we will present our study on teachers‘ perception of the construct of explanatory black boxes which shows that teachers acknowledge the existence of black boxes and their perception of biology heavily influences their perception of black boxes. These results should be taken into account for helping teachers discuss black boxes in their classrooms.

Teaching about the structure of evolutionary and developmental explanations in secondary schools

Kostas Kampourakis*, University of Geneva, Switzerland

ABSTRACT
There is not much research on how secondary students understand the structure of scientific explanations and what distinguishes those from mere descriptions of phenomena, such as evolution and heredity. At the same time, there is a lot of research about the preconceptions that secondary students hold about such phenomena, which are directly connected to their ability to provide explanations. Therefore, more research in how secondary students perceive

and understand the structure of scientific explanations is necessary. In this paper I propose a framework for research and teaching about the nature of developmental and evolutionary explanations to secondary school students. The framework presented in the figure shows the four dimensions (causes/processes, evolution/development) upon which students' understanding can be structured. Therefore, a crucial first step could be their understanding of the respective features (What is a cause? What is a causal process? What is a cause or a causal process in evolution or development?). Understanding the structure of scientific explanations is necessary for understanding their potential, as well as their limitations. The framework for research and teaching proposed in this paper might pave new ways forward.

Epistemic aims, explanation types, and evolution learning

Ross Nehm*, Stony Brook University, USA
Evan Abreu, Stony Brook University, USA
Gena Sbeglia, Stony Brook University, USA

ABSTRACT

Although explanation is a core scientific practice, different life science disciplines (e.g., molecular biology, evolutionary biology) prioritize different forms of explanation in accordance with their field's epistemic aims. Trommler and Hammann (2020) proposed four types of biological explanation, three of which may productively account for the same biological phenomenon in different ways (etiological, constitutive, contextual). Along with inappropriate teleology, these types of explanations have been operationalized as a coding scheme for students' evolutionary explanations produced in response to the validated ACORNS instrument. We categorized >2,000 undergraduate explanations of evolutionary phenomena in plants and animals before and after instruction. We quantified types of explanations, associations among types, and changes in types across plant and animal phenomena before and after a unit on NOS and evolution. Pre-test we found: particular forms of explanation central to evolutionary explanation (etiological or backward-looking) were the least common in both plants and animals; different explanation types were weakly associated; and inappropriate teleology was somewhat common. Post-test, we found: etiological explanation types increased substantially; inappropriate types decreased; and greater explanatory diversity, consistency, and association occurred across phenomena. These findings provide new insights into the practice of biological explanation and challenges inherent to explaining living phenomena.

Applying a classroom simulation with chatbot to support pre-service biology teachers' diagnostic competence in evolution

Daniela Fiedler*, IPN Kiel, Germany
Daniel Schönle, Furtwangen University, Germany
Christoph Reich, Furtwangen University, Germany
Ute Harms, IPN Kiel, Germany

ABSTRACT

Teaching evolution processes requires the teacher's diagnostic competence (i.e., the ability to assess students' evolutionary explanations accurately). However, during biology teacher preparation at university, respective learning opportunities are rare. Digital technologies like

classroom simulations offer new ways to address this gap. The classroom simulation for evolution education included in this study provides real-like classroom situations in which pre-service teachers are prompted to perform formative (i.e., evaluate evolutionary explanations) and summative assessments (i.e., assess virtual students' overall performance). A chatbot is integrated and interacts with the user by answering queries and giving feedback automatically (i.e., without human intervention). This study investigated how a classroom simulation for evolution education combined with a chatbot influences pre-service biology teachers' diagnostic competence. So far, 62 pre-service biology teachers participated in the first round and diagnosed 1703 evolutionary explanations, of which participants correctly diagnosed 33%. Pre-service teachers often have trouble identifying the evolutionary principles of variation and selection and threshold concepts (i.e., randomness, probability, and time scales). Our study provides insights into innovative digital opportunities to support pre-service teachers' professional development when practical situations are scarce.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Dialogue and Argumentation in Learning Science
4/20/23, 8:40-10:10, Salon A2 (LL)

Displaying uncertainty in collaborative interaction: a turning point in students' making sense of SSI online

Anne Solli*, University of Gothenburg, Sweden
Miranda Rocksen, University of Gothenburg, Sweden

ABSTRACT
Uncertainty is a fundamental aspect of epistemic practices including those involving navigating complexity of socio-scientific controversial issues. Working with such issues online is challenging and the understanding of students uncertainty in these activities is still limited. In this paper we study how students display and attend to uncertainty when engaged in collaborative inquiry using a digital visualization tool for handling online information on HPV vaccine. We present a ‘telling case' showing how, in the course of talk, display of uncertainty results in a change of discourse orientation. The multimodal analysis shows how uncertainty is produced in coordinated interaction through talk, prosody, gestures and bodily orientations and becomes a resource for further inquiry. Through the analytical approach we are able to show how uncertainty in this situation is related both to student relations and to the content. The students articulate what constituted uncertainties for example how to categorize an actor, issues of trustworthiness, how to identify important actors from the visualization, and how to use the visualization to explain the controversy. The uncertainty displayed is also related to students' different contributions and foci when solving the task at hand. Finally we discuss the importance of understanding and encouraging displays of uncertainty.

Pair Dialogue in the Context of Computational Modeling

Linsey Brennan*, Michigan State University, USA
Namsoo Shin, Michigan State University, USA
Emil Eidin, Michigan State University, USA

Daniel Damelin, The Concord Consortium, USA
Joseph Krajcik, Michigan State University, USA

ABSTRACT
New visions for science teaching and learning (including A Framework for K-12 Science Education) focus on integrating disciplinary core ideas, cross-cutting concepts, and science practices. Computational modeling contexts align with this vision and provide evidence of collaborative sensemaking through constructive dialogue between students as they build their model. This study explores the dialogue of a pair of students (who have different social and cultural backgrounds) as they participate in computational modeling. Screencast videos of the pairs were recorded as they participated in computational modeling, and the videos were transcribed and coded using a coding scheme. We found that student-to-student on-task dialogue decreased over time and student-teacher interactions increased. These findings highlight the role of the teacher as a synergistic scaffold (with curricular materials and learning tools) in supporting student-to-student dialogue and collaborative sensemaking. Future directions will examine how professional learning can help teachers support their students (especially students of different racial and gender identities) in collaborative sensemaking.

Developing Middle School Students' Socioscientific Reasoning through Integrated STEM Education

Nilay Ozturk*, Bahcesehir University, Turkey
Gillian Roehrig, University of Minnesota, USA

ABSTRACT
This study aims to explore how middle school students' socioscientific reasoning (SSR) (complexity, perspective-taking, inquiry, skepticism, affordances of science) changes after they were thought an integrated STEM unit designed and implemented in the context of a regionally-relevant SSI. In this pre-post intervention design study, a modified version of The Quantitative Assessment of Socioscientific Reasoning (QuASSR) was used to assess students' SSR and a rubric was utilized to analyze the data. Analyses showed that both before and after the intervention, students scored the highest on perspective-taking and the lowest on inquiry. The Wilcoxon Signed Rank Test revealed a significant increase with a large effect size in perspective taking and a small effect size in complexity and affordances of science. Analysis also showed that students could use variety of sources when they reason about each of the SSR dimensions. Findings indicated that implementing integrated STEM unit in SSI context improved students' complexity, perspective-taking, and affordance of science related SSR; however, more research is needed to explore how integrated STEM approach could be used to improve higher level SSR competencies such as inquiry and skepticism.

To evoke or not to evoke students' preconceptions in argumentation-based inquiry

Lena Lenz*, University of Education, Germany
Tobias Ludwig, University of Education, Germany

ABSTRACT
In scientific arguments, hypotheses are linked to data (e.g., from experiments (Authors, 2017)). In physics lessons, according to well-known models of experimentation, learners are instructed to express hypotheses about physical relationships before conducting an experiment (Nawrath et al., 2011). In most cases, specialist knowledge is not yet known, and the hypotheses are often based on everyday-life experiences (Schecker et al., 2018). Learners then rely heavily on previously activated, insufficient preconceived notions when evaluating data. Against this background, this study shows how forming a hypothesis before conducting an experiment impacts justification. For this study, 136 students were divided into three groups: A, B and C Group A formed a hypothesis before the scientific inquiry, which was based on everyday life experiences. Group B received an indication of the possible outcome of the inquiry task. Group C evaluated the data without making a hypothesis in advance or receiving an indication of the outcome of the inquiry. This approach aimed to determine whether the omission of hypotheses leads to the argumentation of the learners becoming technically more adequate. This lecture presents the results of the study.

Strand 3: Science Teaching - Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set: Supporting Science Content Knowledge for Elementary Teachers
4/20/23, 8:40-10:10, Salon C1-2 (LL)

Exploring how Lived Experiences Mediate Science Identity and Agency of Induction Phase Elementary Teachers

Swarna Mahapatra*, University of Missouri, USA
Rebekah Snyder*, University of Missouri, USA
Sara Bridgewater, University of Missouri, USA
Laura Zangori*, University of Missouri, USA

ABSTRACT
This work is situated in hermeneutic phenomenology and explores how induction phase elementary teachers mediate their science identities and science teaching actions. We use Colliers (2001) notion of reference roles which is a perceived role of what it means to identify with a specific community. This was a qualitative multiple case-study where each participant is an individual case. All participants were enrolled in an M.Ed level science methods course. Data was collected throughout the course (interviews, reflections, discussions, and lesson plans). We analyzed the data corpus for markers of past and current critical events the teachers perceived as impactful and were used to determine their reference role. Results suggest that each teacher held a reference role they used to mediate their science identity and determine if they could take science teaching actions. When the reference role was external to themselves (such as hands-on activities) then they were able to shift towards a science teaching identity and actions. However, when the reference role was internal to themselves (needing a "science brain") then they did not attempt science teaching actions. Our

implications include the importance of supporting elementary teachers to use an external science reference role to take science teaching actions.

Preservice Elementary Teachers' Initial Knowledge for Teaching of the Crosscutting Concepts within Three-Dimensional Teaching

Anna Maria Arias*, Kennesaw State University, USA
Soon Lee*, Kennesaw State University, USA

ABSTRACT
Used in conjunction with the disciplinary core ideas and science and engineering practices in three-dimensional (3D) learning, the seven crosscutting concepts (CCCs) (e.g., cause & effect; systems & system models) can allow for deeper understanding of how and why phenomena work through equitable sensemaking. To support this sensemaking of phenomena, teachers need knowledge for teaching of the CCCs. However, more information is needed about how teachers develop knowledge of the CCCs related to 3D learning. In a qualitative case study of their knowledge of the CCCs in 3D learning, we analyzed the responses of seventy-four preservice elementary teachers to a questionnaire focused on their knowledge of the CCCs for teaching. We also analyzed nine think-aloud interviews about the questionnaire. Our analyses showed patterns and variation across the PSTs' responses on the CCCs questionnaire and their interviews. For example, the quality of PSTs' responses about the relationship between the CCCs of patterns and cause & effect and elementary teaching scenarios were typically more accurate and complete compared to the CCC of systems & systems models. Implications for teacher educators, curriculum developers, and science educational researchers around supporting 3D learning and developing instruments are discussed.

Exploring Elementary Teachers' Subject Matter Knowledge Development in the First Year of Teaching

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Adam Bennion*, Brigham Young University, USA
Alexandra Swain, Brigham Young University, USA
Elizabeth Tagg, Brigham Young University, USA

ABSTRACT
Teachers' own classrooms are an important location for their learning, but little is understood about what and how teachers learn in this setting. In this study, we seek to explore how elementary teachers' learning through teaching experience—particularly how their science subject matter knowledge for evolution and matter changes over the course of their first year of teaching, seeking to understand factors that support or inhibit their learning. This longitudinal, mixed-methods study finds that many new elementary teachers do, in fact, learn science SMK over their first year of teaching without formal professional development. Surprisingly, however, the factors we explored (demographics, knowledge monitoring, teaching experience, and teaching context) did not predict of changes in teachers' SMK. These data suggest a need for greater nuance in approaching these factors: for example, it may not just be how aware teachers are of their own knowledge, but how they respond to the feeling of not knowing. While many teachers did improve in their SMK over the first year, this was not a trend for the full

sample. While teaching experience can lead to SMK learning, this does not happen for many teachers.

Understanding Teachers' Transition to Knowledge Generation Environments after a Professional Development Program

Jale Ercan-Dursun*, The University of Alabama, USA
Ercin Sahin, University of Iowa, USA
Jee Suh, The University of Alabama, USA
Qi Si, The University of Alabama, USA
Brian Hand, University of Iowa, USA
Gavin Fulmer, University of Iowa, USA

ABSTRACT
In this research, we aimed to understand why some teachers struggle with adapting the knowledge generation approach to science teaching while others were more comfortable with the change. We conducted a case study with twelve elementary teachers who participated in a professional development program about a knowledge generation approach called Science Writing Heuristic. Data was collected through various sources, including interviews and open-ended teacher reflections about the professional development program. First, we analyzed teachers' epistemological and ontological views to determine the teachers who struggled with the knowledge generation approach vs. teachers who were more comfortable with it. Then, we analyzed teachers' commitment, learning, and concerns/interests to explain the differences in their change and transitions to knowledge generation environments. Our analysis showed that teachers who struggle with the knowledge generation approach started the PD as a school/district-driven investment. Their learning happened mainly at the informational level, and they developed a limited understanding of how epistemic tools can help students' knowledge generation. Struggling teachers also have mostly personal concerns about their ability to implement change and the appropriateness of the change. Finally, we discussed the implications of our model for teacher professional development and change.

Strand 3: Science Teaching - Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set: Supporting Elementary Teachers to Teach Science
4/20/23, 8:40-10:10, Blvd C (L2)

Elementary Science Teachers' Explicit and Implicit Verbal Support of STEM+CS in an NGSS-Aligned Project

Sarah Lilly*, University of Virginia, USA
Anne McAlister, The State University of New York at Buffalo, USA
Jennifer Chiu, University of Virginia, USA

ABSTRACT
National frameworks for science education in the United States have worked to bring science, technology, engineering, mathematics, and computer science (STEM+CS) disciplines together through curricula in K-12 classrooms. This study describes how two elementary teachers verbally supported fifth-grade student engagement in a NGSS-aligned project that integrated science, engineering, mathematics, and computer science within two disciplinary-focused lessons (i.e., science lesson and computer science lesson). Transcripts of whole-class discussion were analyzed for instances of interdisciplinary integration in which teachers verbally supported the integration of disciplines to help students to engage in STEM+CS activities. Results indicated that, across lessons, teachers most commonly added verbal support for the integration of mathematics. In the science lesson, the majority of the instances were added and explicit; there were no instances of planned support that were made explicit. In the computer science lesson, most instances were added and implicit; planned instances were evenly split between being made explicit or implicit. Implications of this study include recommendations for support that teachers need to engage in the important, but challenging, work of enacting STEM+CS curricula within elementary science classrooms.
Keywords: interdisciplinary, teachers' verbal support, elementary

Teaching science through dialogue and argumentation: practices and challenges identified by Chilean educators and researchers
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Natalia Candido Vendrasco, Pontificia Universidad Catolica de Chile, Chile

ABSTRACT
Learning science involves developing a discourse aligned with science concepts and ideas that need to be supported by teachers and curriculum materials. However, in Chile, scientific discussions and argumentation in elementary schools are very recent (Mineduc, 2012), and teaching is mainly content-centered with few opportunities for student interaction. Given the relevance of science teaching that promotes dialogic interaction and argumentation, it is essential to understand why teachers need to implement these practices and what might prevent them from doing so. In this study, we investigate teachers' challenges and practices when facilitating productive science discussions and argumentation in elementary classrooms. We focus on Chilean teachers' dialogue and argumentation practices, investigating the challenges of their particular context through in-depth interviews with schoolteachers, teacher educators, and researchers. We found that practices facilitating science discussions have dialogic/interactive purposes, grant roles to teachers and students, and involve participation structures, discourses, and teaching practices. Teachers' perceptions of discussion and argumentation practices show that they have seldom implemented them even though they know them. Data also shows that challenges lie in teacher preparation and beliefs as well as institutional constraints.

An Exploratory Study: Understanding Teachers' Use of Decomposition
Ali Asif*, University of Massachusetts Dartmouth, USA
Hamza Malik*, University of Massachusetts Dartmouth, USA
Chandra Orrill, University of Massachusetts Dartmouth, USA

Ramprasad Balasubramanian, University of Massachusetts Dartmouth, USA
Shakhnoza Kayumova, University of Massachusetts, USA

ABSTRACT
Advancements in the field of Computer Science (CS) and its growing role in scientific endeavors have put forth a challenge to include Computational Thinking (CT) in science and engineering practices of K-12 students. The increased demand to bring CT to K-12 education has put teachers, especially Science Technology Engineering and Mathematics (STEM) elementary teachers up to a challenge. Within CT, Decomposition is considered as one of the major constructs hence making it a mandatory skillset for the teachers to understand and practice. This exploratory qualitative research study focuses on ways in which these elementary grade STEM teachers utilize the concept of decomposition to solve a community garden bad harvest problem during a professional development workshop session. We investigated the audio and video recorded of the session of one group of teachers (three in total). The data analysis was carried out from a community of practice (CoP) perspective using deductive schemes and predefined codes/categories connecting back to our conceptual framework. Results suggest that even though considered difficult to understand, all three teachers' mutual engagement, their sense of mutual accountability, and their own negotiated meanings pushed them to utilize functional decomposition regularly while solving the bad harvest problem.

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

SC-Organized Paper Set: NGSS Implementation: Inquiry, Science and Engineering Practices

4/20/23, 8:40-10:10, PDR 2 (L3)

Multiple Case Study of Science and Engineering Integration in Secondary School Across Six School Districts

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Elizabeth Lewis, University of Nebraska-Lincoln, USA

ABSTRACT
A multiple case study was conducted to investigate six districts' approaches to integrating science and engineering curricula in their secondary education programs. Data collected included classroom observations, interviews with teachers and administrators, college transcripts, professional development, and curriculum, as well as how, and how district personnel supported, and teachers enacted classroom instruction to align with the NGSS. Six districts were chosen due to their ranges in their size, urban or rural context, and demographics. There were 25 participants in the study who were either district personnel or secondary teachers. All school districts in the study incorporated STEM into their program through either extracurriculars, courses, and/or formal focus programs, regardless of their size; however, engineering integration was not consistent across science instruction. Also, although

two of the districts have required curriculum for their middle schools that integrates engineering, teachers may or may not use the engineering portions of these curricula. Professional development (PD) offerings for teachers ranged in availability due to the size and rural or urban context of the districts; however, none of the districts offered engineering-specific teacher PD. As science teachers have limited experience with engineering, districts and educational service units need to provide long-term engineering-specific teacher PD.

Balancing Standards Alignment with Educator Needs

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Abigail Helmke, Waterford Union High School, USA
Joseph Hendricks, Waterford Union High School, USA

ABSTRACT

Despite nearly a decade since the release of NGSS, there is little evidence of large-scale changes in US science instructional practices. Local norms, values, and expectations have significant influence on teacher decisions and are often in tension with three-dimensional science learning. As a team of biology instructors, we report our experiences and insights gained from developing standards aligned curriculum that is responsive to our local needs. We address two research questions in this paper: 1. What approaches enable NGSS alignment in a manner that is responsive to the needs of local educators? 2. To what extent were these efforts perceived as successful and why? We found that a number of strategies were key for balancing NGSS-alignment with educator needs. These included weekly packets that provided a flexible roadmap for scaffolding student sensemaking; a mixture of graded and ungraded assessments with both one- and three-dimensional questions; a low-inference system for enabling reinforcement among at risk students; and a simplified approach for consistent grading on open-ended responses. Despite early skepticism, over time our team felt that our new materials were easier to implement, were more responsive to district expectations, improved student engagement, and yielded more robust three-dimensional student outcomes.

Understanding of Scientific Inquiry and Its' Relation to Academic Achievement: A Large Scale Study

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Nevin Aslan, Marmara University, Turkey
Mustafa Cakir*, Marmara University, Turkey
Serhat Irez, Marmara University, Turkey

ABSTRACT

There are conflicting reports not only on the effect of scientific inquiry on academic achievement but also insufficient evidence on the relationship between understanding the nature of scientific inquiry and academic achievement, more generalizable studies are needed. The purpose of this large sampled study was to investigate the middle school graduates' understandings of scientific inquiry and the relationship between students' understandings of SI and academic achievement. The sample of the study (X=3067) was selected by purposeful and layered-sampling techniques among 9th students studying at high schools with different

orientations in Istanbul. Descriptive and inferential statistical approaches were used in the data analysis procedure. The students' academic achievement was operationally defined as the scores they received in the High School Entrance Exam. VASI scale was applied to determine the participants' understandings about scientific inquiry. The data were collected in the first two weeks of the first semester of high school in accordance with the purpose of the study. The results of the study revealed that middle school graduates generally do not have adequate understandings of SI. Furthermore, according to the findings except for the ‘conclusion-data conformity' aspect, there are statistically significant correlations between students' academic achievement and understandings in all aspects.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Undergraduate Research Experiences
4/20/23, 8:40-10:10, Salon A4 (LL)

From Sepsis Case to Course-based Undergraduate Research Experience: Student Learning Outcomes and Views

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Rebecca Krall*, University of Kentucky, USA
Robin Cooper, University of Kentucky, USA
Melody Danley, University of Kentucky, USA
Jate Bernard, University of Kentucky, USA

ABSTRACT
Course-based undergraduate research experiences (CUREs; Archensloss, et al., 2014) are becoming more common in undergraduate biology as they create a novel approach for undergraduate students to experience scientific research while offering faculty pathways for connecting their research to in-course experiences. This parallel mixed methods study sought to explore students' views about a CURE and their understanding of cardiac anatomy and physiology following their participation in a mini CURE (i.e., one laboratory session with pre and post assignments). The research conducted in the CURE tested the effect of bacterial endotoxin (lipopolysaccharide, LPS) on frog and larval Drosophila heart function, research that was built on a recent study (Anyagaligbo et al., 2019) that emerged from a life-threatening medical case. Learning outcomes were measured using pre and post content assessment from matched pair responses (n=42). A post survey was used to collect student views, which were analyzed qualitatively using a constant comparative method (Corbin & Strauss, 2012). The results demonstrated statistically significant increases in students' content knowledge. Students' views highlighted the importance of authentic bench research experiences to build laboratory, collaboration, and problem-solving skills, and to support the development of a more realistic understanding about science and how scientific knowledge is constructed.

Development of a Measure of Science Teams for NSF CUREs

Joi Walker, East Carolina University, USA
Richard Lamb*, East Carolina University, USA

Concurrent Session 7, 4/20/23, 8:40-10:10

Heather Vance-Chalcraft, East Carolina University, USA

ABSTRACT
Collaboration in science has become a critical practice and is much more prevalent in industry and university courses than it was a decade ago. In response to the increased emphasis on collaboration and team science, educators at all levels of the K-16 educational context have sought to create generative learning environments which leverage team practices using interdisciplinary content. Team or Convergent Science is research conducted by more than one individual in an interdependent fashion, including research conducted by small teams and larger scientific groups. The purpose of this study is to illustrate the validity and reliability of a newly developed measure of Team Knowledge and Skills (TKAS) related to team science implemented in an undergraduate research based interdisciplinary course setting. The overall study design was a non-randomized intact multiple administration design. Administration of the survey occurred over multiple semesters with adjustments to the survey occurring after administration. The intent of the adjustments is to iteratively develop the underlying psychometric properties of the TKAS. The TKAS is a psychometrically sound instrument. Successfully tracking adjustments in student TKAS, it becomes possible to create more effective teams, can lead more students to choose STEM careers, and allow students to be more job ready.

Instructor conceptions and implementation of course-based undergraduate research experience (CURE) features

Kristine Callis-Duehl*, Donald Danforth Plant Science Center, USA
Ruth Kaggwa, Donald Danforth Plant Science Center, USA
Lisa Walsh, Donald Danforth Plant Science Center, USA

ABSTRACT
Course-based undergraduate research experiences (CUREs) uniquely defined by five features/attributes; use of scientific practices/process, iteration, collaboration, broad relevance, and discovery, are a unique form of pedagogy that incorporates authentic research into classroom teaching. Despite their contributions to improving student outcomes, CUREs are not widespread. Insights into the conceptions and practices of instructors implementing CUREs might inform CURE dissemination efforts towards increased adoption and improved student outcomes. The goal of our study was to investigate instructor conceptions of the CUREs to identify how that knowledge and understanding influences their implementation. We developed a survey targeting biology undergraduate instructors and shared it over 15 professional scientific organization directories. Our respondents comprised 53 instructors who had experience with CUREs. Of the five CURE dimensions/features, instructors varied on their conceptual understanding of discovery and broad relevance, more than any other aspect of a CURE. Furthermore, only a few respondents include broad relevance and iteration in implementation of their CUREs relative to the other three. Our findings suggest the need for greater professional development efforts focused on the framework of CUREs and a revision of the current framework to incorporate new instructor suggested aspects such as student-centered communication.

Concurrent Session 7, 4/20/23, 8:40-10:10

Examining the Activities Associated With Students' Career Clarification During Undergraduate Research Experiences

Alicia Batailles*, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT

Undergraduate research experiences can be beneficial for students majoring in STEM disciplines. Some of these benefits include, clarification of career goals, personal and professional development, establishing collegial, working relationships with mentors and peers, and thinking and working like a scientist (Seymour, et. al. 2004). It is important to understand how different components of the undergraduate research experience impact these benefits for students. Two questions motivated this work: What characteristics of the mentor-protégé relationship are linked to greater clarity of long-term career plans for undergraduate researchers? and What sorts of research activities are linked to greater clarity of long-term career plans for undergraduate researchers? The study described the development and validation of a survey to describe factors associated with an undergraduate research experience. The resulting survey included eight subscales and 40 items. That survey was administered to a group of 188 undergraduates who participated in an undergraduate research experience. The results suggest that increases in students' agency in learning, confidence irrelevant to research, and application of knowledge and skills are more strongly correlated with students' more general career clarification than their more specific interest in continuing to graduate school.

Scientific Reasoning Competencies: Fostering and Analyzing Procedural, Content-related and Laboratory-Technical Components in the Undergraduate Lab

Marco Reith*, Institute for Science Education, Leibniz Universität Hannover, Germany
Andreas Nehring, Institute for Science Education, Leibniz Universität Hannover, Germany

ABSTRACT

Scientific reasoning competencies enable to conduct scientific investigations using experiments. This requires goal-oriented integration of components such as procedural knowledge, content knowledge, and laboratory-technical knowledge. To promote these competencies in higher education, adapting experiments from traditional lab courses to more open formats is a suitable approach. This contribution presents differentiated research on such an approach: Four experiments from a traditional introductory lab were adapted according to the principles of guided inquiry, combined with measures that have proven to be effective in fostering scientific reasoning competencies and sequenced coherently to support competencies development. The learning sequence was evaluated globally as well as differentiated with regard to different competency components (procedural, content, and laboratory-technical) based on written lab reports. The results indicate significant improvements in the quality of scientific investigations conducted within the sequence. The differentiation with regard to the components provides deeper insights: While an increasing number of procedural and content-related criteria were fulfilled, this effect was not found for laboratory-technical criteria. These findings demonstrate the capability of differentiated assessment to detect potential for improvement and the effects of interventions more precisely.

Based on this, interventions can be developed that are tailored to the specific needs of students.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Supporting Science Teacher Learning through Interactions with Science Research
4/20/23, 8:40-10:10, Salon A1 (LL)

Creating a community of K-8 teachers to co-design moth research with students

David Stroupe*, Michigan State University, USA
Megan Walser, Michigan State University, USA

ABSTRACT

This paper, reports on a project which we call InsectLife, and addresses the critical question - How can we support teachers to design for student participation in authentic science? - from two perspectives. First, from the perspective of a design problem, this project explores the design of resources, materials and supports that can foster the opportunities necessary for elementary and middle school students to take up epistemic agency to develop ownership of, and participate in, authentic science investigations involving moths (Author, 20XX). Second, this project investigates how teachers plan to establish, negotiate, and examine participatory roles as they create science in their classroom community over time. Using a framework of Cultural Historical Activity (CHAT), we examined how 7 teachers (spanning grades K-8) worked to create an initial community of colleagues to co-design moth research with students. We found that participants publicly noted the immense value of building a community of colleagues, that teachers noted the importance of building strong connections between their students as scientists from the university, and that teachers focused on different aspects of planning and community building depending on their grade level.

Fostering STEM Career Pathways by Creating a Geoscience Education Community Around Local Geologic Phenomena

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Adjoa Mensah, University of Nevada, USA
Mayra Marquez-Mendez, University of Nevada, USA
Monique North, University of Nevada, USA
Kristoffer Carroll, Clark County School District, USA
Pamela Burnley, University of Nevada, USA

ABSTRACT

Southern Nevada presents a unique geological landscape that highlights scientific phenomena that high school students can leverage to learn about geology and geology-related career fields (e.g., cryptotephra, desert pavement, groundwater). This NSF-funded Project focuses on creating a community of geoscience educators through a collaboration between high school geology teachers (n=14), district administration (n=1), geo-educational researchers (n=3), and

geologists (n=9). In the first phase of this project, we asked 1) When learning and teaching about local geologic phenomena, what aspects of the process do high school geology teachers value towards improving their praxis and building community? And 2) How does being a part of an educationally focused geoscience community impact teachers' teaching efficacy around local phenomena? We conducted a mixed methods study (QUAL/quant) and found a co-occurrence of codes all highly linked to teachers' ideas of community (e.g., professionalism, expertise, praxis), with the exception of fieldwork/lab tours, where the latter focused on individual/personal growth. Additionally, a nonparametric Wilcoxon sign test found growth in teachers' efficacy around teaching with local phenomena. This proposal explores and presents these findings in more detail.

Research Experiences for Teachers: A Review of the Literature

Karen Woodruff*, Kean University, USA
Suzanne Patzelt*, Montclair State University, USA

ABSTRACT

Research Experiences for Teachers (RETs) are available to teachers as professional development. Yet, their design and implementation is diverse. The purpose of this literature review is to develop a typology of RETs guided by the following research questions: 1) What are the current models for research experiences for teachers represented in the academic literature? 2) What claims does the existing literature on RETs make about supporting teachers' development as science educators? The authors conducted a systematic review of literature using Dawson's (2014) framework to identify common elements of programs to operationalize defining criteria for design of future programs intended to support teacher's development. Authors contend that although future implementations of RET programs will likely include some elements from existing RETs, there is a need to critically consider methodological approaches beyond that of self-reported teacher data. Additionally, expertise of teachers as well as researchers should be foregrounded in the design and implementation of future RETs. This work is timely for informing policy supporting programs that bridge researchers with educators, to provide authentic opportunities for all teachers and all students, a cornerstone of NGSS-based reform efforts.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set: Professional development and support
4/20/23, 8:40-10:10, Salon C7-8 (LL)

Making informed decisions: Documenting how physics programs shift towards a culture of assessment

Diana Sachmpazidi*, University of Maryland, USA
Chandra Turpen, University of Maryland, USA
Robert Dalka, University of Maryland, USA
Fatima Abdurrahman, University of Maryland, USA

ABSTRACT
As calls for increased accountability influence institutional practices, a cultural facet that has received increased attention is the culture of assessment. In this project, we study the change process enacted by local Departmental Action Teams (DATs) resulting from physics faculty members' participation in the Departmental Leadership Action Institutes (DALIs). Following a collective case study approach, we investigate three DALI participating physics programs in-depth. We followed these case study programs for over a year, collecting data from multiple sources. Drawing on interviews with physics faculty change agents we investigate cultural shifts. In particular, we document the departments' dominant culture around the use of data and how the emerging microculture within the DATs is situated within that dominant culture. For example, we found that past data collection efforts were a primary responsibility of a single person, rarely becoming the focus of joint attention. Whenever data received joint attention, it was approached in a rushed, surface-level way without meaningfully informing the change effort. However, we found that within the DATs, data played a significant role in understanding the problem at hand. Finally, we found that a broad set of DAT stakeholders engaged in extensive collective discussions around data collection and sensemaking.

The Research and Engagement Academy: A Model for STEM Faculty Development
Eleanor Abrams*, University of Massachusetts Lowell, USA

ABSTRACT
Many universities require STEM faculty to secure external research funds as part of their promotion process, however, financial support of research by governmental agencies and foundations is shrinking. Professional development can play a key role in supporting faculty members' ability and motivation to write proposals. This chapter examines the effectiveness of one such professional development initiative, the Research and Engagement Academy (REA). REA is based upon a faculty learning community model designed to increase the quantity and quality of proposals submitted by STEM faculty. Results of a faculty survey and programmatic assessments offer evidence of the types of impact that the Academy had on proposal development by faculty participants.

Responsive collaborative design of 3D assessments with science teachers
Miray Tekkumru-Kisa, RAND Corporation, USA
Jill Wertheim*, WestEd, USA
Ozlem Akcil Okan, Florida State University, USA

ABSTRACT
There is a growing need in classroom assessments that support 3D science learning, but few quality assessments exist. We introduce a co-design model for the development of complex assessments intended to leverage the specialized expertise of teachers to design equitable and intellectually-demanding assessments in ways that maintain a reasonable load for teachers. This model is designed to be responsive in that it attends to and leverages teachers' thinking, while also being expansive by incorporating feedback from the enactment of the assessments by the teacher and students. Seven science teachers were involved in the initial design of three performance assessments over the course of six months. The initial design

phase was followed by the implementation of these assessments for refinement and improvement during the following academic year. Drawing on the video recordings and artifacts from the co-design meetings and implementation of the assessments in science classrooms, and debrief meetings following implementation, our analysis provides insights into the ways in which teachers shaped the design of assessments.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Beyond Binaries: Interrogating Normativity, Marginality, and (Un)Belonging in STEM Higher Education
4/20/23, 8:40-10:10, Salon A3 (LL)

A qualitative exploration of Latinx students' impostor experiences in science
Devasmita Chakraverty*, Indian Institution of Management Ahmedabad, India

ABSTRACT
Impostor phenomenon is a psychological condition when people do not fully ascribe their success to ability/competence, attributing it to luck, other's generosity, or misjudgment, thereby experiencing an internal conflict. Latinx individuals' impostor experiences related to their ethnic identity are poorly documented and have not considered stereotyping/micro-aggression as potential contributors. Using a framework of identity-based "othering," this qualitative study examined the research question: "How do Hispanic/Latinx PhD students describe reasons they experience impostor phenomenon in science?" US-based participants were recruited using convenience/snowball sampling. Semi-structured interviews were conducted with 22 participants who self-reported experiencing impostor phenomenon. Interview transcripts were coded and analysed inductively using constant comparison to develop themes. Four themes included: lack of gender and ethnic diversity; stereotyping and invisibility; a culturally different learning space; and being the diversity enhancer. This study found that identity-based impostor experience occurred through lack of acknowledgment of one's minority status based on gender, race, and other marginalizing identities, creating a sense of (un)belonging. Especially, female participants experienced impostor phenomenon due to both, gender and ethnicity. This study could lead to developing institutional strategies to support those who experience impostor phenomenon due to their identity and minority status.

Transgender and Minority Gender Students' Sense of Belonging in Higher Education
Tulana Ariyaratne*, Indiana University, USA
Gayle Buck, Indiana University, USA

ABSTRACT
Gender classification is increasingly discussed and challenged. As a socially constructed system, it is defined at structural, symbolic, and individual levels within a society. Many members of the society accept that gender is no longer understood within a binary classification system of male and female, but are confused as to how gender is currently understood. Researchers still attempt to study gender minorities and sexual orientation-wise minorities together under the large LGBTQIA+ umbrella. This ambiguity results in students

finding their identities being figured and reconfigured by their academic institutions - and sometimes a person cannot find themselves within the system being used. Research has shown that when students feel as if they do not belong within the academic institution, their academic progress is hindered. The purpose of this study was to enhance our understanding of nonbinary gender minority university STEM majors' sense of belongingness. This exploratory mixed methods study considered the variations of belongingness between STEM and non-STEM majors that identify as nonbinary. The experiences of the participants were explored through the use of a semi-open-ended survey and individual interviews. Findings showed the participants often experienced problems with the institutes and entities that have traditional binary gender foundations.

Queering the glass ceiling: Gender hierarchies in academic physical science
Katherine Doerr*, Malmö University, Sweden

ABSTRACT
Increasingly in higher education, teaching undergraduate physical science is the job of non-tenure track faculty (NTTF). Because physical science is normatively masculine while teaching is normatively feminine (Keller, 1985; Williams, 1995), both male and female NTTF experience contradictory gender tensions. This inquiry explores a contradiction: how can feminist solidarity help women in science advance, if the institution negates their full and equal inclusion? They are not faculty, they are non. To make sense of these contradictions and answer new questions, I turned to queer theory, which makes a pointed critique of binaries. Reading the data against theory with a diffractive analysis, I find that working within the system to counter sexism is close to futile because those in power use diminishment to divide and conquer.

Movement expressiveness in a chemistry lab as embodied knowledge or off-task behavior
Molly Weinburgh*, Texas Christian University, USA

ABSTRACT
US schooling continues to marginalize students of color even as science education reform documents espouse ‘science for all'. This study, situated in a chemistry laboratory at a university, explores the role of movement expressiveness as an enactment of engagement and learning. Two theoretical stances (social-semiotic and post-structuralism) provide a lens for the investigation. The case study investigates one African-American males' (Christian) movement expressiveness during a three-week, immersive chemistry laboratory experience. Data include video, interviews, and student lab notebook. Video were watched and notes made as qualitative data interpretation and analysis does not happen via mechanistic coding, reducing data to themes, and writing up transparent narratives that do little to critique the complexities of social life. Attention was paid to theory related to movement and embedded knowledge while thinking about deconstruction as not assuming that what is ‘normal' or ‘accepted' is natural. Rather, what is now ‘normal' is a human construct that is an artifact of policy, history, institutes, and society. Data were not seen as centered, but as arrested/suspended in a time and place by virtue of being captured on video. Data interpretation constructs a description of Christian's movements and their impact. Implications for learning science are outlined.

Concurrent Session 7, 4/20/23, 8:40-10:10

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Centering STEM Faculty: Supporting Persistence and Leveraging Perspectives toward Antiracist Work
4/20/23, 8:40-10:10, Salon C5-6 (LL)

Female Perceptions of STEM: Reflecting on why they matter

Mary Curtis*, Independent Researcher, USA
Carol Waters*, University of Houston-Clear Lake, USA

ABSTRACT

Science, technology, engineering, and mathematics can improve lives fundamentally, provide problem-solving skills, and help understand the world (Gulen, 2019; NRC, 2014). Today, the world relies on STEM knowledge and innovations in daily lives. 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 of STEM 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). Intersectionality provides a multifaceted lens that could address inequality within STEM (Collins & Bilge, 2020), of which gender may further understand these disciplines (Misra et al., 2021). This qualitative study conducted four semi-structured focus groups with female faculty and students at Southern Regional University. 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.

Reflections on Inclusive Pedagogy among STEM Faculty during Teaching TRIOS Peer Observation Process

O. Theresa Ayangbola*, Middle Tennessee State University, USA
Sarah Bleiler-Baxter, Middle Tennessee State University, USA
Fonya Scott, Middle Tennessee State University, USA
Olena James, Middle Tennessee State University, USA
Amanda Lake Heath, Middle Tennessee State University, USA
Grant Gardner, Middle Tennessee State University, USA
Gregory Rushton, Middle Tennessee State University, USA

ABSTRACT

National calls to mitigate the attrition rate for underrepresented minorities (URMs) suggest that faculty need to be equipped to teach diverse students (Austin, 2011). A renewed focus on inclusion in STEM classrooms has led to a need to increase awareness and adoption of inclusive teaching practices among STEM faculty. This study describes the implementation of a year-long professional development program in inclusive pedagogy for STEM faculty. Nine STEM faculty in chemistry, biology, and mathematics participated in a Faculty Learning

Community (FLC). We focused on the Teaching TRIOS phase- a peer observation model, whereby teams of three engage in a three-part iterative process of observing, reflecting, and debriefing on one another's classroom practice (Authors, 2021). The data source for this study were the recordings of the debrief sessions. A case study research design was used to explore these questions: (1) In their reflections on inclusive pedagogy during the Teaching TRIOS debrief sessions, what do STEM faculty participants prioritize? (2) When instructors discuss the most prioritized aspects of inclusivity, in what ways did they reflect on their practices? We explore the aspects of inclusivity that faculty find easily accessible while reflecting on inclusive pedagogy.

Building Equity-minded Science Educators and STEM-C Faculty: Faculty Learning Communities (FLCs) in Postsecondary Environments

Shari Watkins*, American University-CTRL, USA
Meg Bentley, American University, USA
Ellen Feder*, American University, USA
Nate Harshman, American University, USA
Lauren Weis*, American University, USA
Amy Butler, American University, USA
Kathryn Water-Conte, American University, USA

ABSTRACT
This proposal explores the connections between participation in FLCs, science educators, and engagement in equity and antiracist work. Data was collected from nine STEM-C faculty across multiple disciplines to understand the ways participation in FLCs impacted their engagement in equity and antiracist work. McNair et al.'s (2020) equity-minded framework was employed as the theoretical perspective to unearth the mode of thinking STEM-C faculty engaged to do equity and antiracist work. Our findings focus on the opportunities that FLCs afford STEM-C faculty to do equity and antiracist work. We offer implications for science educators interested in understanding the ways participation in FLCs builds science educators and STEM-C faculty to engage in equity and antiracist work

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Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set: Using Computational and System Thinking to Support Science Learning
4/20/23, 8:40-10:10, Blvd A (L2)

CT Integration with science and math curricula through teacher-researcher co-design

Amanda Peel*, Northwestern University, USA
Delan Hao, Northwestern University, USA
Michael Horn, Northwestern University, USA
Uri Wilensky, Northwestern University, USA

ABSTRACT
Computing is becoming essential to STEM practice, innovation, and discovery. To integrate computational thinking into core science and math courses, teachers need to learn about CT-STEM and develop curricular resources that fit their classroom needs. This proposal investigates units co-designed by 10 teacher/researcher teams after a four-week professional development institute focused on developing CT-STEM knowledge and curricula. Results indicate teachers were able to integrate the full range of CT-STEM practices within their co-designed curricular units to varying extents. Computational modeling was the most integrated practices, while computational problem-solving practices were integrated the least. A comparison across biology, chemistry, physics, and statistics units is presented, and implications are discussed.

K-5 Accessible, Computational Thinking-Integrated Science Education: A Conceptual Framework

Janice Mak*, Arizona State University, USA
Lin Yan, Arizona State University, USA
Man Su, Arizona State University, USA
Kristina Kramarczuk, University of Maryland, USA
Ebony Terrell Shockley, University of Maryland, USA
Diane Jass Ketelhut, University of Maryland, USA

ABSTRACT
Accessible Computational Thinking in Elementary Science Classes within and across Culturally and Linguistically Diverse Contexts (hereafter referred to as ACT) investigates ways to equip elementary science teachers with skills and dispositions to provide experiences for all students to participate in and engage with computer science (CS) and computational thinking (CT) by incorporating culturally responsive teaching (CRT) practices. To bridge theory to practice, our research team co-constructed a research-based, innovative conceptual framework, the ACT Framework, that reflects the integration of CT and CRT into science instruction. This ACT Framework was then used to develop professional learning experiences and a metacognitive ACT-Lesson Reflection Tool (ACT-LRT) for elementary science teachers. Our theoretical paper presents the ACT conceptual framework and accompanying ACT-LRT while addressing the following questions: 1) How can we develop a research-based conceptual framework to support teachers to integrate CT and CRT into science teaching? and 2) How can we use this conceptual framework to create CT- and CRT-aligned science PD experiences for teachers?

Asynchronous Online or Blended/ Hybrid: Implementing Learning Experience Design to Support Students Learning Behaviors

Joseph Wong*, university of california, irvine, USA
Lindsey Richland, university of california, irvine, USA
Brad Hughes, university of california, irvine, USA

ABSTRACT
This study is part of a series of in situ design-based research investigations within a large public R1 university in California, assessing undergraduate science instruction while distance

learning. It has become increasingly important to identify sustainable learning alternatives to support online teaching and learning while integrating educational technologies informed by evidence-based practices of pedagogical learning experience design (LXD). Consequently, this design-based research efficacy study aimed to test the effectiveness of asynchronous online and blended courses supporting or hindering students' learning experience. The study results revealed that there were no significant differences in final grades by course modality. Results also showed that learners who experienced the blended course modality showed increased levels of online engagement, self-regulation, and critical thinking, while learners in the online course revealed greater instances of page views and online course participation. Implications on how institutions may iteratively design and effectively foster successful science online teaching and learning with the deployment of innovative digital learning grounded in pedagogical learning experience design are discussed.

Fostering Pre-service Science Teachers' Systems Thinking via an Asynchronous Online Course

Dov Dori*, MIT, USA
Roee Peretz, Technion, Israel
Yehudit Judy Dori, Technion, Israel

ABSTRACT

Abstract: Science and technology create an ecosystem that is becoming increasingly more knowledge-intensive, complex, and interconnected. Among 21st skills that should be fostered, the next generation science standards include systems thinking and modeling as major components. We examined the effect of an online interdisciplinary asynchronous course on the development of systems thinking and modeling skills among pre-service science teachers. The research question of this qualitative study aimed to characterize the effect of the course on the assignments that the pre-service teachers developed and their related reflections. We present a couple of case studies of two pre-service science teachers. Within an asynchronous food-related online course, they designed an online assignment aimed at fostering their students' systems thinking via modeling. The research tools were self-designed online assignments, which were analyzed using a rubric, and participants' reflections. The rubric enabled scoring and fine differentiation of the two case studies. Reflections exposed the benefits of the online course and system-thinking-related challenges. The contribution of the study is the formation of a theoretical and methodological framework for the integration of interdisciplinary assignments to foster systems thinking in science teacher preparation programs.

Strand 14: Environmental Education and Sustainability

SC-Organized Paper Set: Considering teacher development at the secondary school level

4/20/23, 8:40-10:10, Astoria (L3)

Cross-national survey of science teachers' perceptions of school communities: Implications for curriculum and teacher development

Xavier Fazio*, Brock University, Canada

ABSTRACT
Engaging students in authentic and meaningful learning activities nested in their school communities through environmental sustainability projects is an important curricular innovation. This requires science teachers to have competencies to design engaging curriculum materials in school-community contexts based on sustainability issues. Researchers interested in pursing such collaborative efforts need to effectively assess teachers' views of school science and local community contexts to better implement effective curriculum. Currently, there is no dedicated survey focused on science teachers and local school communities. An instrument called the 'science teacher and local communities' survey was designed to meet this research gap with the aim of providing a starting point for professional learning design, and to assess the potential of developing school and community environmental science projects. Using descriptive and inferential statistics from a cross-national survey administered to elementary and secondary science teachers (n= 205) across Canada provided construct validity of this survey and elucidated statistically significant differences when comparing elementary and secondary science teachers, with elementary teachers overall viewing community-based science teaching opportunities more positively. Future studies may consider utilizing this survey instrument in different contexts to support research focused on community-based STEM programming.

Unpacking the connections between climate literacy and sense of place among Bedouin teachers in Israel.

Shaima Alokbe*, Ben-Gurion University, Israel
Orit Ben Zvi Assaraf*, Ben-Gurion University, Israel
Wisam Sedawi, Ben-Gurion University, Israel

ABSTRACT
The phenomenological study presented here explores the connection between climate literacy and sense of place amongst secondary-school science teachers in the Bedouin community of the Negev Desert in Israel. The literature suggests that the role of teachers in helping students to make informed decisions regarding climate change is crucial but challenging. Moreover, while knowledge remains a critical component of climate literacy, there is growing evidence that communities with a strong sense of place may be more likely to engage in environmental practices. Our study first addresses the teachers' experiences in their environment as residents, parents, and members of their community, and then draws upon their roles as teachers to elicit their insights regarding how climate change might best be addressed locally through place-based education. Our research highlights the importance of sense of place and context in developing climate change literacy. Our interviews with the ten respondents revealed their strong affinity with their natural rural environment and the immediacy of their lived experiences of climate change. The teachers reflected on their roles as educators, and expressed opinions about how place-based learning can be used to help students understand and address climate change at the local level.

Concurrent Session 7, 4/20/23, 8:40-10:10

School-Based Outdoor Science Education K-11 Teachers' Declared Practices in the Province of Québec, Canada

Jean-Philippe Ayotte-Beaudet, Université de Sherbrooke, Canada
Metzisochil Boily-Ortéga, Université de Sherbrooke, Canada
Asmaa Khayat, Université de Sherbrooke, Canada
Élise Rodrigue-Poulin, Université de Sherbrooke, Canada
Marie-Claude Beaudry*, Université de Sherbrooke, Canada
Valérie Vinuesa, Université de Sherbrooke, Canada
Félix Berrigan, Université de Sherbrooke, Canada

ABSTRACT

The outdoors is particularly conducive to learning associated with the natural sciences, because no matter where you are, there are always natural phenomena to discover and understand. However, based on our knowledge of the scientific literature, there is still little research studying the authentic practices of teachers, namely those that they carry out outdoors without the influence of a specific research intervention. The aim of the research presented in our paper is to describe outdoor school-based science teaching practices at the elementary and secondary levels in terms of students' learning. In order to address our aim, we conducted exploratory qualitative research. A total of 14 elementary (grades 1-6) and 12 secondary (grades 7-11) teachers in the province of Québec, Canada, participated in the interviews about school-based outdoor science education. We used inductive categorial content analysis on the written transcriptions of the interviews. We agreed on seven codes to capture teachers' outdoor science education practices: intentions, outdoor environments, planning, disciplinary core ideas, science practices, teaching methods, and assessment. The main finding of our research is that teachers who voluntarily participated in this study showed it is possible to teach a wide variety science learning regardless of their school's immediate surroundings.

Concurrent Session 8
4/20/23, 10:30-12:00

Publications Advisory Committee
Sponsored Session: NARST/NSTA Annual Research Worth Reading Recognition
4/20/23, 10:30-12:00, Salon C1-2 (LL)

NARST/NSTA Annual Research Worth Reading Recognition

ORGANIZERS
Dante Cisterna, Educational Testing Service, USA
Lindsay Lightner, Washington State University, Tri-Cities, USA
Emily Dare, Florida International University, USA
G. Michael Bowen, Mount Saint Vincent University, Halifax, Nova Scotia, Canada
Cynthia Crockett, Harvard-Smithsonian Center for Astrophysics, USA
Knut Neumann, IPN-Leibniz-Institute for Science and Mathematics Education, Kiel, Germany

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:

Anwar, S., Menekse, M., Guzey, S., & Bryan, L. A. (2022). The effectiveness of an integrated STEM curriculum unit on middle school students' life science learning. Journal of Research in Science Teaching, 59(7), 1204- 1234. https://doi.org/10.1002/tea.21756

Ibourk, A., Hughes, R., & Mathis, C. (2022). ‚Äú It is what it is‚Äù: Using Storied-Identity and intersectionality lenses to understand the trajectory of a young Black woman's science and math identities. Journal of Research in Science Teaching, 59(7), 1099- 1133. https://doi.org/10.1002/tea.21753

Lowell, B. R., Cherbow, K., & McNeill, K. L. (2022). Considering discussion types to support collective sensemaking during a storyline unit. Journal of Research in Science Teaching, 59(2), 195- 222. https://doi.org/10.1002/tea.21725

Awards Committee
Sponsored Session: A Celebration of NARST Award Recipients: Early Career Research Award [ECRA], Outstanding Dissertation Research Award [ODRA], and NARST Fellows Award.
4/20/23, 10:30-12:00, Waldorf (L3)

A Celebration of NARST Award Recipients: Early Career Research Award [ECRA], Outstanding Dissertation Research Award [ODRA], and NARST Fellows Award.

ORGANIZERS
Amelia Gotwals, Michigan State University, East Lansing, MI, USA

PANELISTS
Heidi Cian, Florida International University, USA
Hsin-Kai Wu, National Taiwan Normal University, Democratic People's Republic of Korea
Hosun Kang, University of California - Irvine, USA

ABSTRACT
This panel session will highlight the accomplishments and contributions of the recipients of the Early Career Research Award [ECRA], Outstanding Dissertation Research Award [ODRA], and NARST Fellows Award. It will provide a platform for a brief discussion of the award recipients” scholarly contributions and how their research trajectories are framed and/or intersect with the theme of NARST 2023.

Roundtables Session 2
4/20/23, 10:30-12:00, Salon A5 (LL)

Topic 1: Supporting beginning teachers

Strand 8: In-service Science Teacher Education
Collaboration as a Key Factor in Secondary Science Teacher Induction
Dennis Sunal*, The University of Alabama, USA
Cynthia Sunal*, The University of Alabama, USA
Sabrina Stanley, The University of Alabama, USA
Marsha Simon, University of West Georgia, USA

ABSTRACT
Collaboration was investigated as a factor in the development of reform science teaching through an induction program for novice inservice secondary science teachers. Theoretical grounding was based on social learning theory as developed through organizational learning theory and communities of practice research in a place-based environment. Following BS graduation in a science discipline and certification in a Master's level program participants

were involved in an intensive induction program. The four-year induction focused on equitable instruction in high-needs schools and teacher leadership development involving continuous integrated Professional Learning Communities (PLC). A sequential explanatory mixed method study was conducted to explore how a collaborative in an induction supports equitable reformed science teaching performance. Data were collected from multiple classroom observations, semi-structured interviews, and PLC meeting transcripts over the four years. Results found significant growth in equitable reformed inquiry science teaching and in professional identity growth. Collaboration through continuous involvement in PLCs during induction fostered participants' development of leadership skills strengthening professional identity which was found to be related proactive involvement and innovation as a teacher in the classroom, and in the school community. Science teacher induction must go beyond emphasizing traditional professional development to be able to implement classroom reform practice.

Strand 8: In-service Science Teacher Education

"I would go crazy without them": Narrative inquiry into novice science teacher community of practice

Sabrina Stanley*, The University of Alabama, USA

ABSTRACT

How does a novice science teacher experience membership into an existing community of practice? Membership into the teacher community can support the advancement of skills for novice teachers beyond classroom management and toward developing effective pedagogy. Community of practice (CoP) is a social theory describing groups of people who work collectively within a given setting to share in contextual learning (Lave & Wenger, 1991). This narrative inquiry utilized a CoP lens to explore newly hired teachers' participation with the teacher community to bring to light the participant's life experiences revealing what they value in their work environment. The methodology includes data collected through semi-structured interviews and observations of one novice science teacher and their mentors over the course of an academic year. This study focuses on the interactions between novice and experienced science teachers, the networking of resources as co-workers, and the work among these teachers to set goals and implement curriculum. This project yielded findings that reveal relationships between teachers greatly influence the daily interactions and pedagogy of the novice teacher as they develop into a science educator. Schools and administrators can use these results to promote cohesion and productivity among their teachers.

Strand 8: In-service Science Teacher Education

Understanding Science Teacher Persistence: Examining intersections of instructional Quality and Teaching Contexts

Danielle Rhemer*, Florida State University, USA
Jennifer Schellinger, Florida State University, USA
Miray Tekkumru-Kisa, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT
As we work to make our schools more equitable, it is often recognized that the most important factor in shaping students' learning is the quality of their teachers (Darling-Hammond et al., 2009). Two influences on teacher quality are a teacher's approach to instruction—that is, their instructional quality (Colley & Windschitl, 2016) and their classroom experience (Darling-Hammond et al., 2009). This study looks for insight into how instructional quality might affect persistence. We examined eight science teachers' artifacts to gain insights into how teachers conceptualize quality instruction at the one-year and five/six-year mark. Regarding persistence, we examined interview data to understand their professional trajectory and what they described as factors influencing their retention. A cross-case analysis was then completed to see if there was any correlation between these analyses. Our findings suggest that novice teachers have the ability to design and enact rigorous lessons, however, after gaining experience, teachers conceptualize rigorous instruction similar to how they did as a novice (50%). The major influence on their persistence was a lack of administrative support to develop and enact high-quality instruction. Thus, novice teachers whose approaches represent rigorous instruction may be in a precarious position in terms of their persistence.

Topic 2: Re-situating Science Teaching and STEM Identities within Community and Politicized Care

Strand 11: Cultural, Social, and Gender Issues

We Need Something to Last: Exploring Funds of Knowledge and Community Cultural Wealth

Katherine Wade-Jaimes*, University of Nevada, USA

ABSTRACT
This proposal explores the funds of knowledge and community cultural wealth of a group of five Black/Latina women in a large city. All of the women are themselves, or are caretakers for, students in the public school system. As part of a larger critical participatory action research project, the women met regularly to discuss science and science education, building scientific literacy. Qualitative data analysis of interviews and field notes revealed several important themes for understanding how communities build critical scientific literacy understand funds of knowledge. The women indicated that engaging in the conversations supported their understanding of systemic barriers in science education as well as their agency to effect change in education. Additionally, while they struggled to identify science related resources in their community, they did identity community cultural wealth in the people and relationships within their community. The results challenge teachers and teacher educators to work with communities to disrupt narratives about what and where science is in order to recreate a culture of science that is both visible and accessible to populations that have been historically excluded from science and science education.

Strand 11: Cultural, Social, and Gender Issues

Science for Community Well-being, Liberation and Social Transformation: Transformative Learning and Actions for Change

Bhaskar Upadhyay*, University of Minnesota, USA
Marina Aleixo, University of Minnesota, USA

ABSTRACT
This paper focuses on science education that explores how community and teachers can come together to deliberate on community issues that could be part of science teaching and learning. The paper used transformative adult learning theory, liberation social psychology, and deliberative democracy theories to understand how community and teachers seek to bring socially and politically conscious science. The paper collected qualitative data using methods such as focus group interviews, observations, and field notes. The data analyzed showed that the community was keen on science that focusded on issues that they were interested in rather than the school science curriculum. Additionally, there is tension between community adults and the school in the purposes and nature of the assignments and tests the students are asked to complete to pass a grade. Finally, the analysis indicates that there is a great value in the deliberative process to make science education more responsive to community needs.

Strand 11: Cultural, Social, and Gender Issues

With Care and in Community: Humanizing STEM for Black and Latina Girls

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 a 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 7: Pre-service Science Teacher Education

Determination of Integrated STEM Teacher Competencies

Feral Ogan-Bekiroglu*, Marmara University, Turkey
Fatma Caner, Marmara University, Turkey

ABSTRACT
The purpose of this research was to constitute integrated STEM teacher competencies. The research was carried out via Modified Delphi method formed in four rounds and views and opinions of STEM experts (instructors who work on STEM and teachers who have taken STEM education and having practice on the subject) were examined. The following four competency areas were defined within the scope of integrated STEM teacher competencies: Cognitive Characteristics, STEM Teaching Skills, Affective-Motivational Characteristics in STEM Teaching, and STEM Teacher Zone of Proximal Development. Under these competency areas, 14 components and 58 competence items have been created. This study would be a guiding framework for the development of STEM teacher education programs at the undergraduate or graduate levels.

Topic 3: Informal Science and STEM learning

Strand 6: Science Learning in Informal Contexts

Cultivating Equitable STEM Participation Through an Equity Focused Learning Progression

Lezly Taylor*, Virginia Tech, USA
George Glasson, Virginia Tec, USA
Brenda Brand, Virginia Tech, USA

ABSTRACT

Despite reform efforts to diversify STEM, data continues to highlight gaps of participation and achievement. In response, current reform initiatives have touted the implementation of learning progressions as a promising strategy that can produce equality of outcomes. Despite this promising effort, an analytical review revealed that few learning progression studies address equity, and few studies are conducted with groups such as African Americans that have been traditionally excluded from STEM. Current learning progression frameworks that are designed to enhance all students' epistemological participation in STEM bear a universalist approach that ignores sociocultural factors that influence epistemic participation for African American students. This study argues that an equity-oriented learning progression should be responsive to sociohistorical factors that dissociate African Americans identities as epistemic contributors. Qualitative methodology was used to explore how students experienced identity transformation while developing epistemic practices across a pre-engineering learning progression. The findings indicated that repositioning African American students' identities as epistemic contributors is significant to cultivating epistemic agency. Findings contribute to a broader understanding of how equity-oriented learning progressions can promote equitable participation in STEM.

Strand 6: Science Learning in Informal Contexts

Children's Epistemic Agency in Everyday Family Science Engagement

Irit Vivante*, Ben Gurion University in the Negev, Israel
Dana Vedder-Weiss, Ben Gurion University in the Negev, Israel
Neta Shaby, University of Southampton, United Kingdom

ABSTRACT

Family plays a crucial role in children's science learning. As family members interact with their children in everyday life, they may support or hinder the children's epistemic agency. Scholars have emphasized the development of epistemic agency as an essential science education objective. However, while much research has focused on classroom interactions, little is known about children's epistemic agency in everyday life. This self-ethnographic case study explores a naturally occurring episode of family interaction with soap bubbles. Using linguistic ethnographic multimodal discourse analysis, we examined how epistemic agency was manifested during family interaction, and what inhibited or supported it. Our analysis revealed a three-way epistemic relationship between the children, the mother, and the father, afforded the children's epistemic agency but also constrained it. While the mother strove towarsd

epistemological structures of 'doing science,' repeatedly trying to elicit scientific discourse, the children, supported by the father, rejected her attempts as they demonstrated epistemic agency. We found the epistemological dynamics between the parents allowed the children to exert agency. This study adds to the body of knowledge on epistemic agency and has significant implications for shaping family everyday interactions.

Strand 6: Science Learning in Informal Contexts

Genetic Technology & the Use of an Oral Debate Method to Question Ethics in the Classroom

Chaley Cleckley*, Lamar University, USA
Mamta Singh, Lamar University, USA

ABSTRACT

This study aimed to assess the effectiveness of an oral debate in the science classroom regarding stance and content retention on genetic technology and its use in CRISPR-Cas9 with Covid-19. There are many studies on the debate method, but few, if none, assess the effectiveness of this method on content retention (vital to standardized testing) or analyze the change of stance in students. This study explored an argument-based learning method while guiding the participants to explore basic knowledge and understanding of genetic technology and its relation to Covid-19 in humans. Pre-mid-post content knowledge assessments and debate methods were used. The qualitative data from an oral and written debate method were compared against another data source in addition to the assessment scores. Overall, findings suggest that there was little difference in content retention and no change in stance after oral and written debate methods. Larger, prospective studies are warranted to investigate these initial findings further.

Strand 15: Policy, Reform, and Program Evaluation

Development and Evaluation of an Archaeological Afterschool Program to Promote Science Learning

Amber Simpson*, Binghamton University, USA
Laurie Miroff, Binghamton University, USA

ABSTRACT

In this study, we add to the rich scholarship of STEM experiences in informal learning environments by focusing on a novel afterschool program geared towards rural middle school students emphasizing the development of science content, skills, and practices using the field of archaeology and local Indigenous material culture as a medium. We employed a single instrumental case study, which afforded researchers the possibility to evaluate the design of the unique program across three middle school sites. Utilized Honig and McDonald's seven key features of afterschool programs that support learning (e.g., transfer of knowledge across settings; participation in genuine, meaningful work; youth as co-constructors of knowledge), we illustrate how the program aligns with each of the key features. We contend that the significance of this study lies in the potential for professional archaeologists, scientists, and educators within other communities to develop a similar afterschool program to support learners' participation as science learners.

Topic 4: Teaching and Learning NOS from Kindergarten through Graduate School

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

NOS Conceptions and Identity Development among Graduate Students in Science Education

Andrea Phillips*, Indiana University, USA

ABSTRACT

Research on Nature of Science (NOS) conceptions and identity development for NOS contains a gap in the realm of examining doctoral students aiming to be science teacher educators. This research examines the NOS identity development of participants in a course focused on the philosophy of science and research about NOS education. The data analyzed for this study were recordings and notes taken during class discussions in a NOS seminar, as well as NOS research and teaching assignments associated with the course. These data sources were analyzed for development of four influences on identity development for NOS: 1) personal influences on NOS identity, 2) contextual influences on NOS identity, 3) competing identities with NOS, and 4) persistence in overcoming barriers to development of a NOS identity. Findings emphasize the need to target NOS identity development among teacher educators, as they hold the primary responsibility for instilling a NOS identity in their own students, who are future teachers.

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

Influence of engaging texts and immersive experiences on kindergarten students' conceptions of observations and inferences

Valarie Akerson*, Indiana University, USA
Kristen Poindexter, Allisonville Elementary School, USA

ABSTRACT

The focus for this study was to determine whether fairy tales that are commonly known to many elementary students can help them learn about nature of science (NOS), specifically inference and observation, when paired with an engaging experience, such as a mock crime scene investigation. There has been much research done to determine that young children even as young as kindergarten can learn about nature of science aspects and communicate their ideas and understandings about nature of science (Authors, 2011; Authors 2010). Kindergarten students can grow their understandings around NOS through explicit-reflexive teaching and learning along with other evidence-based strategies including the use of children's literature (Authors 2010). A gap exists in the literature that has been published about the use of fairy tales when teaching about NOS. There is little research about immersive experiences such as the mock crime scene investigation when paired with a fairy tale text (Brunner & Abd-El-Khalick, 2020; Ford 2006; Zarnowski & Turkel 2013). However, linking these texts with an immersive experience, such as the mock crime scene investigation, that is explicitly designed to increase students' understanding of inference and observation, could help to teach young children about NOS.

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

College Students' Views of the Nature of Science

Stephanie Rothman*, Indiana University, USA
Jason Rothman, UC Irvine, USA

ABSTRACT

For over 100 years, most scientists, science educators, and science education organizations have agreed upon the goal of aiding students in developing adequate conceptions of Nature of Science (NOS) (Abd-El-Khalick et al., 1998). Indeed, student understanding of NOS is still considered an important educational goal by contemporary science education researchers (Allchin et al., 2014; Olson, 2018). Nevertheless, numerous studies have shown that many students hold naïve views of NOS (Abd-El-Khalick, 2012; Abd-El-Khalick & Boujaoude, 2003; Dogan & Abd-El-Khalick, 2008; Kang et al., 2005; Lederman, 1992) This study adds to the existing literature about students' perceptions of NOS, examining students in the first author's introductory biology online asynchronous class at a diverse Southern California 4-year public M1 university. I examined students' views of NOS before the course started (in a pre-test) and at the conclusion of the course (in a post-test). The students in this study were of various majors, but not biology majors. It is my hope that after participating in my class, where I will use research-based teaching methods, students will develop more informed views of NOS. My study will add to the existing literature about students' perceptions of NOS.

Strand 1: Science Learning: Development of student understanding

SC-Organized Paper Set: Engineering Design and Self-Efficacy to Promote Student Learning

4/20/23, 10:30-12:00, Salon C3-4 (LL)

Reasoning through iteration: How do engineering design projects promote student learning and self-efficacy?

Senay Purzer*, Purdue University, USA
Rundong Jiang, Institute for Future Intelligence, USA
Isaac Lyss-Loren, Purdue University, USA
Filiz Demirci, Purdue University, USA
Jenny Quintana-Cifuentes, University of Louisiana Moroe, USA

ABSTRACT

Reasoning through iteration is a core practice in engineering design. While iteration allows reflection and learning from failure, repeated cycles of failure can hurt the self-efficacy of novice designers. In this mixed-methods study, we studied the design reasoning of high school students as they engaged in an engineering design project with explicit iteration opportunities. We first analyzed pre/post data (N=108) to identify student learning and self-efficacy changes. This stage revealed that students had statistically significant gains in their understanding of solar science concepts and their engineering design self-efficacy; though, solar science

concept scores and design self-efficacy scores were not correlated. We then used purposive sampling to identify five case study students. Anna and Lee conducted multi-criteria experiments and prominently used trade-offs reasoning. Andy and Lucy conducted single-criterion experiments and showed evidence of experiential reasoning. Design reasoning through iterations was fragmented in students with low solar science learning gains. Low design self-efficacy gains were associated with repeated cycles of failures (artifacts that did not meet design requirements), likely due to multi-criteria experiments. Students with high gains in their solar science learning as well as design self-efficacy practiced single-criterion experiments and demonstrated chains of reasoning that likely resulted in learned generalizations.

A New Model of the Engineering Design Process from A Conceptual Change Approach

Christine McGrail*, University of Massachusetts Amherst, USA

ABSTRACT

The engineering design process, currently taught as one big circle, is better represented as a series of recursive small circles, where each small circle represents one design. Artifact design is initiated using the existing knowledge, then, through design testing, an artifact yields new information that promotes changes to the child's thinking, which is then instantiated in the next design. The series of circles reflects the way children hold information in their minds from design to test to new mental model instantiation in the subsequent design. In the new, linear engineering design model we propose, the small circles are interlocking, representing the way the ideas connect and build. This is an important departure t from the dominant engineering design process which suggests that the design stages work individually and come back to the same place. The new model captures the learning process during the engineering design process and reflects that iterations in the design process begin at a new place in conceptual development.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Computational Modeling and Data Analysis in Learning Science
4/20/23, 10:30-12:00, Blvd A (L2)

Telling atoms how to react: Students' learning through computational modeling of chemical reactions using MMM-React

Asnat Zohar, The University of Haifa, Israel
Sharona Levy*, The University of Haifa, Israel

ABSTRACT

The particulate model of matter is a foundational idea that describes and explains many phenomena in chemistry and physics. However, chemical reactions are usually taught as a detached event, disregarding the multiple interactions between molecules, the dynamic nature of the process, and the underlying mechanism. Thus, many students think that substances are joined together, modified, or transformed into products in a one-step process. To this goal, we designed and developed the MMM-React, based on a framework that supports computational modeling with a complex systems perspective. It enables the construction of a variety of models in chemistry and physics with a small set of computational blocks, making a clear separation between properties, actions, and interactions of different kinds of entities. The study uses mixed methods with 60 middle-school students in a pretest-intervention-posttest design. Findings demonstrated a significant increase in students' conceptual understanding, specifically in concepts related to micro-level, the particulate model, and in system components related to emergence. Analysis of students' discourse during interacting with MMM-React shows how the design of the separate computational blocks supported in viewing chemical reactions as parallel events occurring among many molecules with the necessary condition of collisions, after which breaking and forming bonds occur.

The More, the Better? Influence of Different Data Amounts on Cognitive Load and Learning Outcomes

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Tobias Ludwig, Karlsruhe University of Education, Germany
Amy Masnick, Hofstra University, USA

ABSTRACT

Digital measurement has didactic potential for physics labs. For example, new phenomena can be revealed by collecting and evaluating "big data" due to higher sampling rates. Different amounts of measurement data can provide different evidence, and learning outcomes can vary. Likewise, learners' cognitive load (CL) may vary due to the number of data points. Furthermore, evaluating "big data" requires more pronounced data literacy (DL). In a study with 360 students, the relationships among learning outcomes, CL, and DL were investigated. Participants evaluated data sets of different sizes on the stick-slip effect (rattling windshield wipers and squeaky doors), made various hypotheses, assessed their CL, and completed a competency test for the evaluation of graphical data representations. It was found that as the number of data presented increased, the learning outcomes increased, while the CL did not change. The influence of the size of the data set on learning outcomes was moderated by CL, while the influence of DL on learning outcomes was mediated by CL. The results suggest that dealing with "big data" can enhance physics learning and that DL should be promoted, as it is a key player in the evaluation of data.

What dimensions do students notice through computational modeling and data analysis?: An investigation using [Anonymous]

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Adelmo Eloy, Columbia University, USA
Tamar Fuhrmann, Columbia University, USA
Leah Rosenbaum, Columbia University, USA
Paulo Blikstein, Columbia University, USA
Michelle Wilkerson, University of California, Berkeley, USA

ABSTRACT

This paper draws on a larger project in which we design for students to iteratively engage in scientific practices of computational modeling and data analysis. Here, we report on two sixth

grade science classes' work in a unit about how ink diffuses through hot and cold water. Using interaction analysis, we analyzed what dimensions students attended to as they analyzed data, constructed computational models, and compared the two to validate their models. Our analysis led to three findings: 1. Visual cues from video data were salient to students who heavily drew on them to iterate on their models.; 2. Programming computational models raised questions about the behavior of the individual particles in the phenomenon.; and, 3. The visual data made salient the contrasting conditions being modeled. However, instead of developing a single model that explained diffusion in both hot and cold water, students programmed distinct behaviors for each condition. The findings illustrate how visual data and modeling together can help students generate explanations to account for scientific phenomena, and show evidence that students need explicit supports for thinking about models as providing an explanation for a range of related conditions in the system.

A Systematic Review of the Literature on Graphing Statistical Data in STEM Education

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Sarah Malone, Saarland University, Germany
Dominik Thüs, Saarland University, Germany
Stefan Küchemann, Ludwig-Maximilians-Universität, Germany
Sebastian Becker-Genschow, University of Cologne, Germany
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Roland Brünken, Saarland University, Germany
Jochen Kuhn, Ludwig-Maximilians-Universität, Germany

ABSTRACT

Graphing statistical data is an important skill in the science, technology, engineering, and mathematics (STEM) context. Graphs are also used in many everyday situations, for example in newspapers, on data dashboards on the Internet and in education. Moreover, the ability to correctly construct graphs is a valuable skill. To provide an overview of the literature on this important topic, our systematic review identifies how the construction of convention-based graphical representations of statistical data, referred to as graphing, has been studied in previous research and how effective graphing as an instructional activity was. Based on our search term, we look for peer-reviewed studies with English abstracts on graphing in STEM education on SCOPUS, ERIC, and PsychInfo. We use the ASReview software, which applies machine-learning methods, to speed up the screening process. Finally, we consider STEM-related educational and theoretical implications based on the narrative synthesis of the included studies. Primary results indicate a need for comparing graphing practices between disciplines, e.g., between math and other STEM subjects.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set: Honoring Learners' Lives in Informal Science learning
4/20/23, 10:30-12:00, PDR 2 (L3)

Creating accessible and inclusive science camp for deaf students
Scott Cohen*, Georgia State University, USA

ABSTRACT
This study aims to explore deaf students' learning experience through a short-term science camp, one of the science learning spaces in informal science education. An informal science learning environment affords the learning connection inside and outside of their classroom that together can be conceptualized as a learning ecology or ecosystem that could provide supplemental support to deaf students' learning ecosystem (DeWitt & Archer, 2017). There is little known about creating accessible and inclusive learning spaces for deaf students in informal science education. This short-term science camp is a five-day summer STEM camp at a large research university in the Southeast United States. The data was collected in the summer of 2022 as the ongoing analysis, with initial findings on reducing stereotypical perspectives on scientists and harnessing the benefit of a short-term science camp. Including ASL in the science camps produced affinity spaces for deaf students to collaboratively interact with each other to learn about STEM and explore their future in STEM. The importance of understanding who the students are engaged in science learning can lead to a more equitable learning space (Durall et al., 2021).

Supporting Multilingual Children's Learning at Science Museum through Science Talk
Wahyu Setioko*, The Ohio State University, USA
Lin Ding, The Ohio State University, USA

ABSTRACT
Multilingual families are understudied research focus in informal science education literature. They may face challenges that are non-existent in English-speaking families when learning science in informal settings, such as science museums, that are mostly designed and developed in English. This study explored how parents and other family members support multilingual children's learning in a science museum through science talk and interactions with and in the exhibits. We used a microethnograpic discourse analysis approach, which capitalizes on sociocultural contexts to explain how family members used language and physical materials at the museum exhibits to support multilingual children's science learning. Data was collected from video recordings of the family talk and interactions throughout their museum visits, parent interviews, and artifact collection. Results showed that families altered and adjusted the scientific information from the exhibit, displayed in English, before explaining them to their multilingual children in their home language. The science knowledge presented by the exhibit was filtered through the parents' understanding of that knowledge. Furthermore, when explaining scientific knowledge to their multilingual children, the parents used code-switching from their home language to English and, in doing so, left the scientific terms in English.

Towards Epistemic Justice in Socio-scientific Decision-Making: How Youth Make Sense of Lively COVID -19 Data
Wisam Sedawi*, University of Michigan, USA
Angela Barton, University of Michigan, USA

ABSTRACT
Studies of socio-scientific decision-making in times of crises are in their infancy. This study investigates how minoritized youth make sense of newly developed COVID-19 vaccines and their intersections with the evolving multi-pandemic. Guided by theories of lively data and data sense, an epistemic injustice and re-storying methodological approach are used to center the experience of four Palestinian Arab minority youth
in the Israeli context throughout the ongoing pandemic. Analysis of long-form interviews and experience sampling show how youth come to understand the multidimensional nature of the crisis through their first-hand sensory experiences with COVID-19 data, as they navigated the pandemic as youth minoritized by dominant society. Their sense- and decision-making also shifted as the pandemic and reflected how they understood it as a health hazard, vaccine efficacy, the political and scientific narratives and policies regarding the vaccine. The pandemic proposed solutions resonant with the science they understand and in negotiation with broader context broader of local, national and global pandemic data. This negotiation provides insight, specifically when analyzing how the broader view pertains to obstacles and the interplay of local narratives in complicated vaccine sensemaking. The study offers implications for learning with lively data towards epistemic justice in socio-scientific decision-making.

Exploring queer and science identities of LGBTQ+ community and citizen science participants

Todd Harwell*, University of California, Davis, USA
Russanne Low, Institute for Global Environmental Strategies, USA
Allison Mattheis, California State University, Los Angeles, USA
Kelly Riedinger, STEM Research Center, Oregon State University, USA
Heather Fischer, STEM Research Center, Oregon State University, USA

ABSTRACT
Citizen science, a field and practice that commonly involves "nonexperts" engaging in scientific activities and research, is an avenue of science engagement that commonly results in increased learning for volunteer participants. In recent years there have been increasing efforts to better understand additional outcomes, including how personal dimensions, such as their identities, background, cultures, and experiences, contribute to their relationships with citizen science and the broader field of STEM. While previous studies have acknowledged the lack of demographic diversity in terms of gender, race/ethnicity, education, and socioeconomic status, to date there remains little record of the sexual orientation and/or gender identity of citizen science volunteers. The aim of this study was to understand the personal dimensions of engaging LGBTQ+ volunteers in citizen science including the relationships between LGBTQ+ citizen science volunteers' queer and science identities. Based on the perspectives and experiences of 14 LGBTQ+ citizen science volunteers as shared in semi-structured interviews, we suggest that practitioners across the field of citizen science have the power and potential to reduce barriers faced by LGBTQ+ citizen science volunteers by taking actions and enacting strategies that welcome, respect, involve, and retain LGBTQ+ individuals in their projects and programs.

Strand 7: Pre-service Science Teacher Education
Related Paper Set: Investigating How Preservice Teachers Learn to Facilitate Argumentation-Focused Discussions through Online Simulations
4/20/23, 10:30-12:00, Salon A2 (LL)

Elementary Preservice Teachers' Use of Prompts to Encourage Student-to-Student Talk during Scientific Argumentation Discussions

Heidi Masters*, University of Wisconsin - La Crosse, USA
Pamela Lottero-Perdue*, Towson University, USA

ABSTRACT
Learning to navigate student-led argumentation-focused discussions is challenging for preservice teachers (PSTs). To support student sense-making, PSTs need opportunities to practice encouraging student-to-student talk during argumentation-focused discussions. In this study, 16 elementary PSTs practiced facilitating an argumentation sense-making discussion in a Mursion® simulated environment after learning strategies for how to facilitate rich argumentation discussions, including peer talk. The PSTs ranged in their use of two types of prompts to encourage student-to-student talk: (1) requests for students to turn-and-talk, where students talk to one another simultaneously in pairs or small groups; and (2) direct requests for students to talk to one another back-and-forth such that one student talks at a time. Direct prompts that led to student-to-student talk lasted between 39 and 100 seconds. While these findings suggest that PSTs new to argumentation discussions can implement prompts to support student-to-student talk, there is room for growth by the PSTs and their teacher educators.

Examining Preservice Secondary Teachers' Question Patterns in Support of Argumentation-Focused Discussions in Science and Mathematics

Laura Zangori*, University of Missouri, USA
Meredith Park Rogers*, Indiana University, USA
Ronald Hermann, Towson University, USA
Rachel Snider, TNCJ The College of New Jersey, USA
Tracy Hargrove, University of North Carolina Wilmington, USA
Shelby Morge, University of North Carolina Wilmington, USA
Calii Shekell, Thiel College, USA
Heather Howell, ETS, USA

ABSTRACT
Becoming adept at asking questions during argumentation-focused discussions that elicit student thinking and support students' sense-making is challenging and requires rehearsals and simulations. We used a digital simulation environment (MursionTM) to support PSTs' in leading a small group argumentation-focused discussion. Qualitative data analysis occurred through an analytical and theoretical framework exploring how middle school and secondary science and math PSTs attended to student ideas and facilitated a coherent and coordinated argumentation-focused discussion. Twelve PSTs participated in the study (6 Science PSTs; 6

Math PSTs). Results suggest three discussion trajectories over a 20-minute small group discussion: (a) Five PSTs used open-ended questions but switched to directed questioning as it became more challenging to connect students' ideas and reach a discussion conclusion; (b) Five PSTs' used directed questioning to reach a discussion conclusion (c) Two PSTs used direct questioning at the beginning then switched to telling to reach a discussion conclusion. Implications point to the need to support science and math secondary PSTs in figuring out how to sustain discussions and ask questions that provide space for students' ideas to drive the discussion, as well as build coherency or sense-making towards the learning goals (i.e., content) of the lesson.

Preservice Teachers Noticing and Positioning Students as "Knowers" in Equitable Argumentation-Based Discussions

Amanda Benedict-Chambers*, Missouri State University, USA
Lauren Madden*, The College of New Jersey, USA

ABSTRACT

This study investigates how preservice elementary teachers notice and position students as "knowers" in argumentation-focused discussions. Using qualitative methods, we examined how 29 PSTs across two science methods courses analyzed the argumentation-focused discussions they facilitated in simulated classroom discussions using an online simulation. Findings indicate the following: more than half of the PSTs positioned the group as sensemakers and capable of collectively co-constructing knowledge; around 40% of PSTs positioned one student in the group as capable of providing knowledge and teaching the other students; and a small number of PSTs positioned the teacher as the sole holder and manager of knowledge in the discussion. These findings offer important insights about the intersection of teacher noticing for equity and teachers' efforts to learn to facilitate argumentation-focused discussions.

Examining Preservice Teachers' Performances Facilitating Argumentation in a Teaching Simulator

Meredith Park Rogers*, Indiana University, USA
Kady Lane*, Indiana University, USA
Taiwo Ogundapo*, Indiana University, USA
Dionne Cross Francis, University of North Carolina - Chapel Hill, USA
Pavneet Kaur Bharaj, University of North Carolina - Chapel Hill, USA
Arya Karumanthra, Indiana University, USA
Kraig Kitts, Indiana University, USA
Spencer Perry, Indiana University, USA
Adam Maltese, Indiana University, USA
Jamie Mikeska, ETS, USA
Calli Shekell, Thiel College, USA

ABSTRACT

Online simulations or virtual reality environments have the potential to address important issues in teacher preparation, such as honing pedagogical skills to support specific scientific practices. This paper shares the results of 12 preservice teachers (PSTs) performances facilitating argumentation-focused discussions when engaging in a virtual reality simulator called Simulator [name blinded]. Data included the videos of the PSTs' performances in the Simulator. The videos were analyzed using five dimensions of argumentation-focused discussion, which include: 1) attending to student ideas, 2) facilitating a coherent and connected discussion, 3) encouraging student-to-student interaction, 4) developing student's conceptual understanding, and 5) engaging students in the practice of scientific argumentation. Dimensions 1, 2, and 3 averages across all PSTs scored the highest, suggesting the PSTs are near a rating of ‘well-prepared' when it comes to drawing out students' ideas, consistently using students' ideas throughout the discussion, and encouraging student-to-student interaction. However, PSTs scored slightly lower on understanding students' conceptual ideas and the lowest on dimension 5, which focuses on disciplinary specific argumentation skills such as engaging students to critique, revise, and evaluate arguments. Implications for building on PSTs strengths with Dimensions 1-3 to improve skills related to dimensions 4 and 5 will be discussed.

Examining What and How Secondary Science Preservice Teachers Learn from Using Online Simulated Teaching Experiences

Calli Shekell, Thiel College, USA
Jamie Mikeska*, ETS, USA
Pavneet Kaur Bharaj, University of North Carolina, USA

ABSTRACT

In this presentation we will share findings from a pilot study with preservice teachers (PSTs) who were using a suite of simulated online practice tools to support PSTs who were learning to facilitate argumentation-focused discussions in secondary science. The suite, comprised of three different practice spaces, was designed to scaffold PST learning. Both PSTs and their teacher educators (TEs) reported that their main takeaways from using the suite were around how to plan for and ask good questions and how to plan more generally for the discussions. PSTs reported that they used what they learned from one practice space to prepare for the next, specifically what questions to ask and that planning was important. These findings suggest there is value in the coordinated suite of online practice spaces for PST learning.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Teacher Learning around the Epistemic Work of Science
4/20/23, 10:30-12:00, Salon A1 (LL)

Investigating Science Teachers' Professional Vision of Science and Engineering Practices

Yuxi Huang*, University of Georgia, USA
Hong Tran, University of Georgia, USA
Joseph Deluca, University of Georgia, USA
Jose Pavez, Western Illinois University, USA
William Gorton, University of Georgia, USA

Julie Luft, University of Georgia, USA
Brooke Whitworth, Clemson University, USA

ABSTRACT
The Next Generation Science Standards (NGSS) have had a significant impact on science education in the United States since they were released. As a result, science teachers' perception of NGSS and its connection to their professional knowledge and instructional practices are salient since science teachers play a critical role in implementing NGSS in science classrooms. Therefore, we investigated science teachers' Professional Vision of Science and Engineering Practices in this study. Professional Vision is a construct that includes teachers' perception and interpretation, and it is highly related to teachers' professional knowledge and instructional practices. We developed a video-based instrument and analyzed science teachers' responses to the selected video clips from an NGSS perspective. By showing what science noticed and what factors influenced their Professional Vision of NGSS practice, we found most teachers had limited explanations about the practices, and experienced science teachers outperformed in description quality compared to new teachers. These findings provide insights into future teacher noticing study and design of professional development programs for science teacher researchers.

Do Epistemological Beliefs Matter? Investigating Mentor Teachers' Perceptions & Approaches to Supporting Model-Based Science Teaching

Grace Carroll*, North Carolina State University, USA
Matt Reynolds, North Carolina State University, USA
Soonhye Park, North Carolina State University, USA
Amanda Hall, North Carolina State University, USA
Scott Ragan, North Carolina State University, USA
Jason Painter, North Carolina State University, USA

ABSTRACT
Reform-based initiatives in science education position students as epistemic agents of their own learning. Teachers' adoption of these initiatives is often dependent on teacher beliefs about how knowledge forms and how learning occurs, called epistemological beliefs (EBs). Professional developments focusing on reform-based initiatives, which also include mentorship after the training, are promising for promoting reformed science teaching. However, mentors often approach their mentor-mentee relationship in the same way they approach teaching. This qualitative study investigated how mentors, assisting newly-trained teachers in model-based instruction, perceive and approach mentoring and examines whether there were differences based on the mentor's EBs in specific terms of: (1) epistemic alignment, (2) authority relations in learning, (3) nature of knowledge, and (4) student ability. Four mentors, two having EBs more aligned to reform-based science teaching and two with less aligned EBs, participated in interviews. Data revealed three themes: (1) All mentors perceive mentoring as a supportive process of learning to teach as well as emotional support, (2) only mentors with more reform-oriented EBs saw mentoring as being supportive for both the mentor and the mentee, and (3) mentors within the two groups differed in their ideas about communication practices with mentees.

Exploring Teachers' Epistemological and Ontological Views throughout a Professional Development

Ercin Sahin*, University of Iowa, USA
Jee Suh, University of Alabama, USA
Jale Dursun, University of Alabama, USA
Brian Hand, University of Iowa, USA
Gavin Fulmer, University of Iowa, USA

ABSTRACT
Teachers' epistemological and ontological views are critical factors to achieve shifting from traditional replicative environments to knowledge generation environments. The aim of this paper is to explore the development of teachers' epistemological and ontological views and how these changes are related to teachers' transition to knowledge generative environments. This investigation takes the form of a multiple-case study of 12 K-5 teachers. Data for this study were collected using teachers' semi-structured interviews, reflection surveys, and classroom observations. A codebook was designed based on the literature to assess teachers' alignment to generative and replicative epistemological and ontological views. Overall, the results illustrate that every teacher changed their epistemological and/or ontological views in terms of replicative and generative ideas after the professional development workshop. The teachers in the struggle and slow categories have low or medium implementation level, and the teachers classified as moderate and fast adapters have medium or high level of implementation. In addition, we did find some differences between the concerns of teachers, which may affect their transition of epistemological and ontological views. This paper should be of interest to NARST members engaged in continuing professional development of teachers, pedagogical knowledge, and instructional strategies.

Productive Struggle and Epistemic Empathy: Developing Teachers' Modeling Orientation in a Community Science Context

Lauren Saenz*, Bowdoin College, USA
Alison Miller*, Bowdoin College, USA
Christine Voyer, Gulf of Maine Research Institute, USA
Meggie Harvey, Gulf of Maine Research Institute, USA
Sarah Clarke, Bowdoin College, USA

ABSTRACT
This proposal reports on a two-year case study investigating the role of productive struggle (Hiebert & Grouws, 2007; Manz, 2018) and epistemic empathy (Finkelstein, Jabar, and Dini, 2019; Jaber et al., 2020) in a design-based research context focused on modeling in science. The dual foci of this case study are the design of a Professional Learning Community (PLC) and teachers' experience of the PLC. Data sources include interviews with participating teachers, video observations of weekly PLC meetings and summer institutes, and 'classroom artifacts' from various sources. Researchers used NVivo software to code and analyze data; this analysis resulted in four overarching categories of findings. First, this approach fosters epistemic empathy through productive struggle on multiple levels, enhancing teacher learning by offering

multiple opportunities to play different roles (student, teacher, scientist). Second, we found cumulative effects of incorporating ‘empathetic experiences' in the PD design; meaningful integration requires time, reflection, and repetition. Third, immersion as teacher-learners leads to epistemic breakthroughs about content and self-learning. Finally, learning alongside teachers offers project team members opportunities to gain deeper insight by "tuning in" the experiences of others. The authors identify implications for future work in teacher professional learning, particularly in the context of modeling in science.

Strand 10: Curriculum and Assessment
SC-Organized Paper Set: Examining student performance in science learning
4/20/23, 10:30-12:00, Salon C7-8 (LL)

Examining Aspects of Integrated STEM Education and Student Attitudes
Benny Mart Hiwatig*, University of Minnesota, USA
Gillian Roehrig, University of Minnesota, USA
Mark Rouleau, Michigan Technological University, USA

ABSTRACT
Integrated STEM education (iSTEM) has been promoted as an effective approach not only to develop scientific and mathematical literacy among learners, but also to improve student attitude towards learning STEM and thus promoting students' pursuance of STEM-related careers. While there are existing studies that investigated the relationship between certain iSTEM activities/ curricula and change in student attitudes, there is a lack of research examining the operationalization of iSTEM and its aspects in relation to change in student attitudes towards STEM and the role of demographic variables in predicting these outcomes. Thus, the current study used multilevel modeling and an exploratory approach to accomplish such objective. The findings suggest that the main effects of the aspects of iSTEM on changing student attitudes towards STEM are not significant with respect to the data. However, some of these aspects of iSTEM become important when looking at their interaction with demographic variables such as gender and race in terms of predicting attitudinal change. Furthermore, students in some classrooms tend to have greater change in their attitudes toward STEM than in some other classrooms that cannot be explained by the measured variables. This suggests that contextual effects matter, and they need to be further explored.

Diagnosing Middle School Students' Scientific Modeling: Cognitive Diagnostic Modeling Approach
Yu Zhang*, Northeast Normal University, China
Peng He*, Michigan State University, USA
Tingting Li*, Michigan State University, USA

ABSTRACT
Developing scientific modeling competence is one of the critical goals in international science education. This study applied the cognitive diagnostic modeling (CDM) approach to examine students' cognitive patterns of developing and using models. We localized three assessment

tasks and developed six cognitive attributes accordingly. Responses from 211 grade 9 students from two middle schools were collected, scored, and analyzed. The results show that the six cognitive attributes developed are reliable and valid for identifying students' cognitive challenges in scientific modeling. In addition, we found that the biggest challenge for middle students making sense of phenomena with developing and using models. That is, they use disciplinary core ideas to explain phenomena without the practice of developing and using models. However, they do not have a deep understanding of the crosscutting concept (quantity).

Multi-level Structural Equation Modelling for the Factors Affecting Korean Middle School Students' Science Achievement

Gyeong-Geon Lee*, Seoul National University, Korea, Republic of
Heesoo Ha, Seoul National University Center for Educational Research, Korea, Republic of
Hun-Gi Hong, Seoul National University, Korea, Republic of

ABSTRACT
Science academic achievement is a construct for examining the consequence of students' science learning. Although Korean middle school students' high science achievement has been reported via international assessments such as TIMSS and PISA, a more context-specific investigation of its factors has rarely been conducted. Also, the impact of COVID-19 that necessitated remote teaching in global educational sites on students' science achievement has also not been researched much. This study constructed a multi-level structural equation model to investigate factors affecting Korean middle school students' science achievement. Analysing the National Assessment of Educational Achievement data, we delineate individual- and school-level variables that affect students' science achievement. Before the COVID-19 (2018–2019; N = 5,771 and N = 5,614, respectively), primarily individual-level variables such as science affective domain, self-efficacy, and self-studying time were found to have significant effects on science achievement. Meanwhile, after the COVID-19 (2020; N = 4,623), school-level variables such as principal's supervision, school climate, and science teacher's efficacy also have appeared to have significant effects on science achievement. This study contributes to the understanding of the characteristics of high-achieving Korean middle school students and the role of school community that sustain students' learning in situations like the COVID-19.

A Curriculum Analysis of The Sources of Data and Data Engagements of Science Students

Amanda Garner*, University of Tennessee, USA
Joshua Rosenberg, University of Tennessee, USA

ABSTRACT
While many of the science and engineering practices defined in the Next Generation Science Standards have been widely researched and supported through design and development projects, the fourth practice—analyzing and interpreting data—has been the subject of less attention. At the same time, there have been growing calls to involve students in the analyses of complex data sources—even before they reach the high school level. To understand how students are supported in their use of scientific data, we conducted a curriculum analysis of two commonly-used, open-access science education curricula, one from Open Sci Ed and

CK-12. We focused on how students are involved in the aspects of analyzing and interpreting data practice as detailed in the standards and the type and size of the data students used. We found that both curricula emphasized the use of graphs, though Open Sci Ed involved students in a greater range of activities than CK-12. Further, the curricula both involved graphs and maps; tables were also commonly used in Open Sci Ed, and the data sources used were small. We discuss how these findings suggest how teachers can support students to involve their students meaningfully in their work with data.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set: Rethinking Language in Science, Engineering, and Environmental Education: Historical Dangers and Transformative Possibilities
4/20/23, 10:30-12:00, Salon C5-6 (LL)

Racialized as distant-from-science: U.S. science education research and the pathologization of linguistic diversity

Kathryn Kirchgasler*, University of Wisconsin–Madison, USA
Chushan Wu, University of Wisconsin–Madison, USA
Cynthia Baeza, University of Wisconsin–Madison, USA
Diego Román, University of Wisconsin–Madison, USA

ABSTRACT
In U.S. science education, difference from a norm of English monolingualism has long operated as proxy for a distinct kind of learner. This study examines how U.S. science education research has constituted the ‘Spanish-speaking student' as needing pedagogies historically relegated to lower-track courses. As a raciolinguistic genealogy, this study entailed systematic analysis of how Spanish-speaking students appear in major U.S. science education journals over a century (1921–2021). Analysis suggests that language-based diagnoses of science learning needs have undergone epistemic shifts from relying upon evolutionary hierarchies to developmental scales to statistical disparities. Despite those shifts—and ongoing dissensus—U.S.-based journal articles have persistently projected Spanish-speaking students as having: (a) not-yet-scientific minds via psychological metrics; (b) not-yet-scientific homes via sociological methods; and (c) not-yet-scientific cultural outlooks via anthropological frameworks. Built into taken-for-granted tools are cultural and linguistic norms universalized as scientific. Confronting our field's collective history is crucial to unsettle the raciolinguistic and onto-epistemic hierarchies (Rosa & Flores, 2017; Warren et al., 2020) that locate pathologies within target groups. Professionalized to ‘see' and ‘hear' difference as distance-from-science, researchers and teachers may seek to empower, while inadvertently repositioning bi/multilingual students as needing to develop ‘appropriate' modes of thinking, speaking, and living.

Inclusive STEM Education for "English Learners": Racializing Bi/Multilingual Students as Not-From-Here

Cynthia Baeza*, University of Wisconsin-Madison, USA
Sam Evans*, University of Wisconsin-Madison, USA

ABSTRACT
Within the past few decades, science experts have raised concerns about the United States' position in the global economy, resulting in educational policy and curriculum changes to prepare the country's future workers. Emphasis on preparing bi/multilingual learners classified as "English Learners" (ELs) has led to an increase in educational research to develop teacher preparation programs and tools that support this category of students. For instance, K-12 science and STEM literacy for all have become priorities on the national agenda where presumed distinctions by race/ethnicity and language seem to require differentiated modes of teaching in efforts to be inclusive. However, science education initiatives that seek to include linguistically minoritized populations often rely upon raciolinguistic assumptions that point to the presumed existence of different types of learners. Building upon a double gestures lens that produce new exclusions via efforts of inclusion and the lens of raciolinguistic ideologies, our study aims to examine how a prominent U.S. policy report positions ELs as not-from-here, effectively racializing them as foreign. Our findings include the unintended Othering of ELs in STEM, based on characterizations of their language and learning needs.

Multicompetent Learners in engineering: Towards linguistic and cultural justice in design

Greses Pérez*, Tufts University, USA

ABSTRACT
What is the role of Latinx students' backgrounds in developing engineering solutions? Drawing on perspectives of language and epistemic justice in engineering and science as well as situated learning from the learning sciences, this mixed methods parallel convergent study investigates the relationship between language and cognition in design considerations. It examines the influence of monolingual (English-only) and bilingual (Both Spanish-English) contexts in activating the background of Latinx undergraduates for generating culture and language features in their design considerations. The findings suggest that language contexts influence the quantity and level of features generated in the early stages of the design process and the cultural and language aspects considered in the solution. Explicit instruction to incorporate sociocultural elements also seems to be beneficial for students across language contexts. These findings highlight the importance of expanding pedagogical approaches by bringing the ways of speaking and understanding the world of students as valuable for engineering learning and make both visible and central the role of Black and Brown communities in the design processes. At the same time, it offers a pathway for students to develop a broader understanding of what it means to be, do and think like an engineer.

Situating African American Language within science teacher education

Quentin Sedlacek*, Southern Methodist University, USA
Catherine Lemmi, California State University, Chico, USA
Kimberly Feldman, University of Maryland, Baltimore County, USA

ABSTRACT
The "language of science" is often conceptualized to include extensive use of discipline-specific vocabulary. There are also strong pedagogical rationales for providing students with frequent opportunities to talk and write about science in their own words. Teachers' stances toward the latter practice might be shaped in part by their stances toward dialect diversity; educators who hold positive attitudes toward stigmatized dialects such as African American Language (AAL) might also be relatively skilled listeners and readers of their students' scientific thinking, regardless of what dialect is used to express that thinking. However, there is a small risk that actively teaching teachers to hold positive views toward AAL could sometimes inadvertently reify essentialist beliefs about race. We used pre-post surveys to analyze teachers' science-related beliefs and formative assessment practices in two teacher education courses with AAL content. Teachers with positive views of AAL wrote longer feedback and generated longer inferences in response to student writing samples than teachers with negative views of AAL, regardless of whether the samples included AAL features or discipline-specific vocabulary. Positive views of AAL were also correlated with PCK for science teaching. Contrary to fears, racial essentialism remained constant and was negatively correlated with views of AAL.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Examining the intersections of students' ethnic, racial and science identities in college and beyond
4/20/23, 10:30-12:00, Salon A3 (LL)

Towards understanding the science experiences and identity formation of FilAm students
Johan Tabora*, University of Illinois Chicago, USA

ABSTRACT
Filipino Americans (FilAms) occupy a unique position in the US racial structure because of the Philippines' legacy of colonialism. This study investigates the tension between two structural forces Filipinos experience in science: colonial mentality which idealizes Western culture, and science's domination by whiteness. An instrumental case study was used to explore a FilAm student's sense-making of his science experiences and his identities using the concepts of science identity, recognition, figured worlds, and positionality. The data consisted of memos, recorded conversations, journals, and a sketch. Multimodal discourse and artifact analysis was performed on speech/gesture ensembles. Salient constructs were: three science identities, two FilAm identities, and four FilAm figured worlds. The findings describe how the constructs interacted: (1) tension between his figured world of science and his science identity as a mentor, (2) the tensions between his FilAm figured world of Catholicism and his identity with a science belief system, and his queer FilAm identity, (3) his academic pioneer FilAm identity shaped by not having family in the US as it shapes his science mentor identity. This study hopes to complicate the views of FilAm students beyond the Asian American model minority myth.

Student Heterogeneity and STEM Identity Development in the HBCU Context

Karen Marshall*, Oakwood University, USA
Carmen Bucknor, Oakwood University, USA
Valeisha Ellis, Spelman College, USA
Danielle Dickens, Spelman College, USA
Sylvia Butterfield*, National Science Foundation, USA
Christyn Byrd, Oakwood University, USA

ABSTRACT
Though there is evidence that the development of a robust science identity is beneficial to STEM success among students from diverse backgrounds, more research is needed to understand how historically Black colleges and universities (HBCUs) contribute to STEM identity development. This quantitative study examined STEM majors at two private Christian HBCUs, a co-ed HBCU (University A) and a women's liberal arts HBCU (University B). Participants completed surveys measuring racial and ethnic identity (REI), racial ethnic self-schemas (RESC), and science identity. Results suggest that students at both institutions possess strong REIs associated with academic achievement, although University B students appear to experience greater Connectedness and Embedded Achievement, two of three REI characteristics. Students at both institutions scored high on the Minoritized RESC, the motivation to overcome prejudice to fully engage in society. Post hoc analyses revealed significant differences on the Minoritized, In-Group, and Dissonance RESC. University B students had higher scores on expressing feelings of being Minoritized and Dissonance with American culture, and preference for connecting with similar racial-ethnic peers (In-group), compared to University A students who had lower scores on these factors. These differences reveal the complexity of the racialized identity of STEM majors even within similar academic environments.

A critical approach to examine the racial and science identity formation of Latinx students

Danielle Maxwell*, University of Michigan, USA
Kathryn Hosbein, Middle Tennessee State University, USA
Paulette Vincent-Ruz, New Mexico State University, USA
Ginger Shultz, University of Michigan, USA

ABSTRACT
The narrative that science is objective, value-free, acultural, and rooted within a system of meritocracy constrains the representation and advancement of minoritized groups in science. Although there are initiatives to improve the representation of minoritized groups in STEM, much of this effort focuses on achieving racial or ethnic diversity rather than recognizing students' diverse worldviews and identities in the classroom. This study aims to understand how undergraduate Latinx students at Hispanic-Serving Institutions (HSIs) develop science identities and how racialized experiences may influence this development. In this study we use multiple theories of identity, a critical epistemological perspective, and qualitative research methods to build a conceptual framework and describe the salient experiences of our participants. We interviewed Latinx science majors at three HSIs in the southwestern United States. Our analysis indicates that Latinx students use a variety of racialized identity resources

to negotiate the formation of their science identities, and that positive or negative experiences with these resources can greatly influence their science identity formation. The results of this study provide insights into how Latinx students engage with the culture of science and advance our understanding of how to best support Latinx students throughout their undergraduate science education.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Symposium: The role of nature of science in tackling societal emergencies: An international perspective
4/20/23, 10:30-12:00, Blvd C (L2)

The role of nature of science in tackling societal emergencies: An international perspective

Wonyong Park*, University of Southampton, United Kingdom
Hagop Yacoubian, American University of Armenia, Armenia
Alison Cullinane, University of Edinburgh, United Kingdom
Haira Gandolfi, University of Cambridge, United Kingdom
Noemi Waight, University at Buffalo, USA
Shakhnoza Kayumova, University of Massachusetts, Dartmouth, USA
Jennifer Tripp, University at Buffalo, USA
Feyza Achilova, Dartmouth High School, USA
Andreia Guerra, Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, Brazil
Cristiano Moura, Centro Federal de Educação Tecnológica Celso Suckow da Fonseca, Brazil

ABSTRACT
In recent years, the relevance of science learning to individuals' lives has increased with various global and local emergencies in the past decade. Enduring and new issues in society, such as the climate crisis, COVID-19, misinformation, environmental injustices, and racism, require knowledge of science and engineering to understand and respond to. The aim of this symposium is to reflect on the recent efforts to address societal emergencies in science education and consider directions for science education. Our particular focus is on the role of nature of science (NOS), broadly conceived, in reflecting on and tackling such emergencies. This symposium will bring together science education researchers working in different education systems across the world to share innovative approaches and practices related to NOS in the context of social emergencies and initiate discussions on the issue. Taking an interdisciplinary approach, the presentations will explore the intersections between NOS and other fields such as disaster studies, decolonization, race, and environmental justice in order to address societal emergencies. The examples will illustrate how such efforts can be situated within the unique cultural and sociopolitical contexts in which science education is shaped, which will prompt reflections on the contributions of NOS in various social contexts.

Strand 15: Policy, Reform, and Program Evaluation
SC-Organized Paper Set: STEM and Problem-Based Instruction
4/20/23, 10:30-12:00, Salon A4 (LL)

The Experiences of Undergraduate Saudi Students in the STEM Trajectory: Major Choice and Persistence Intentions
Manal Almalki*, Western Michigan University, USA

ABSTRACT
This study aims to investigate two critical stages inside the STEM trajectory in Saudi Arabia. The first part of the study examines the starting point where potential STEM students make academic decisions to continue selecting STEM majors or switch to non-STEM majors. The second part of the study targets students in STEM majors and explores their persistence intentions in these fields. Two questionnaires were culturally adapted and validated in this study. The results show that the first year of university is an attrition point for potential STEM students. A low level of behavioral and environmental engagement was found among first-year students, and only 31% of them declared STEM for their majors. The second year of university was also found to be critical for students' persistence in STEM. While students across the university showed moderate levels of affective engagement, the second-year students had the lowest affective scores. Second-year students are found to be at a higher risk for leaving, as 26% expressed intentions to change their major out of STEM. The study recommends placing more attention on the influential aspects of students' experiences and providing students with more social and academic support, especially during the early years of the STEM trajectory.

A Systematic Review and Meta-Analysis of the 5E Instructional Model for Improving STEM Educational Outcomes
Joshua Polanin, American Institutes for Research, USA
Megan Austin, American Institutes for Research, USA
Joseph Taylor*, American Institutes for Research, USA
Rebecca Steingut, American Institutes for Research, USA
Melissa Rodgers, American Institutes for Research, USA

ABSTRACT
Drawing heavily on learning cycles and associated research from as early as the 1960s, the Engagement, Exploration, Explanation, Elaboration, Evaluation (5E) instructional model was first introduced in 1990 (Bybee, 1990) and is widely used in STEM education (Bybee et al., 2006). Despite its ubiquity, no thorough systematic review and meta-analysis on the 5E model or its derivatives has been completed. This project fills this gap by providing insight into the model's impacts. Campbell Collaboration guidelines were followed throughout the review process. From our database search, abstract, and full-text screening, we ultimately identified 72 studies as eligible for synthesis. These studies yielded 126 effect sizes (math achievement = 10, science achievement = 76, motivation = 40). Our meta-analytic results indicated positive but heterogeneous treatment effects. For math achievement, the average effect was large and statistically significant but with a wide prediction interval, indicating that the treatment effect is

quite different across studies. The science achievement outcome domain rendered similar results yet the heterogeneity was not nearly as profound. Finally, for motivation, a small average treatment effect was found that was not statistically significant.

Impacts of Problem-Based Instruction on Undergraduate Students' Epistemological Beliefs

May Lee*, University of Groningen, Netherlands
Cormac Larkin, University of Groningen, Netherlands
Steven Hoekstra, University of Groningen, Netherlands

ABSTRACT
To prepare undergraduate students in meeting future challenges, they need to develop 21st-century skills. Epistemological beliefs about the nature and process of knowledge mediate the development of 21st-century skills. Previous studies have shown mixed results on the successfulness of active learning instructional approaches in supporting undergraduate students' development of complex epistemological beliefs. One approach widely used to support this goal is problem-based instruction (PBI). We used a mixed methods qualitative approach to examine how implementing PBI in a physics course (waves and optics) taught at a Dutch university affects students' epistemological beliefs about physics. Analysis of the data collected from the course surveys from the first cohort and a validated survey on epistemological beliefs about physics (CLASS) from the second cohort of students generally showed favorable experiences and shifts in students' epistemological beliefs despite few negative experiences in collaborating with peers and access to resources in the learning environment.

Elementary school science: Building a case for urgent action.

Zoubeida Dagher*, University of Delaware, USA
Tamara Turski, University of Delaware, USA

ABSTRACT
There is a palpable concern that most students in the United States are not proficient in science as measured by their performance on standardized tests such as the National Assessment for Educational Progress (NAEP) and the Trends in International Mathematics and Science Study (TIMSS). Findings from the most recent NAEP assessments reveal that the performance of Black and Brown students, as well as those from non-English language households lag the performance of their white, native language speaking peers (NAEP, 2019). Even though these concerns apply to the entire K-12 grades, we specifically focus attention in this position paper on examining science in elementary school since it is a foundational period for future learning and development of career readiness. In this position paper, we analyze performance scores of 4th-grade students from NAEP and TIMSS studies to provide insight regarding factors that might explain stable or decreased student performance within the US (NAEP) and in comparison to top ranking countries (TIMSS) and explore possible factors that explain these disparities. The paper concludes with implications for science education policy.

Concurrent Session 9
4/20/23, 13:10-14:40

Equity And Ethics Committee
Sponsored Session: Elevating Voices of Ethnically and Linguistically Diverse Learners: Interrogating Dominant Deficit-oriented Perspectives across Reforms, Policy and Practices in Science Education
4/20/23, 13:10-14:40, Salon A4 (LL)

Elevating Voices of Ethnically and Linguistically Diverse Learners: Interrogating Dominant Deficit-oriented Perspectives across Reforms, Policy and Practices in Science Education

ABSTRACT
Key facets of global science education reformation includes examining ways current policies and topics centered in educational equity affect its continued improvement. Oftentimes, dominant narratives surrounding culturally and linguistically diverse learners depict them through deficit frames, failing to acknowledge and leverage the wealth of experience and knowledge that such learners bring into the science classrooms (Jones & Donaldson, 2021; Taylor, 2011). To continually interrogate these perspectives across policy, reforms, teacher preparation and practice (Bacon, 2020), this Administrative Session put forth by NARST's Equity and Ethics Committee seeks to explore ways educational systems need to be both redefined with equitable asset-based perspectives of cultural and linguistic diversity and interrogated regarding their dominant deficit-oriented perspectives. The panelists will reflect upon nuanced challenges and opportunities that global science education reforms bring in terms of educational equity. Their discussions will address how current educational policies/ topics of equity affect science education, particularly regarding race, ethnicity, and language. Panelists will examine the implications and repercussions of reform in light of intersecting equity, culture, social class, history and politics. Panel presentations will be followed by interactive discussions, furthering our understanding of equity-focused science learning and culturally and linguistically responsive pedagogies to empower diverse students and their teachers.

Graduate Student Committee
Sponsored Session: Graduate Student Research Symposium
4/20/23, 13:10-14:40, Salon A5 (LL)

ORGANIZERS
Scott Cohen, Georgia State University, Georgia, USA
Theila Smith, University of Groningen, Netherlands
Ti'Era Worsley, University of North Carolina at Greensboro, USA
Sage Andersen, University of Texas at Austin, Texas, USA
Helen Aptyka, University of Cologne, Cologne, North Rhine-Westphalia, Germany

Klaudja Caushi, University of Massachusetts Boston, Massachusetts, USA
Cathy Cullicott, Arizona State University, Arizona, USA
Savannah Graham, Texas Christian University, Texas, USA
Roxanne Gutowski, University of Cologne, Cologne, North Rhine-Westphalia, Germany
Suzanne Poole Patzelt, Montclair State University, New Jersey, USA
Andrea Reeder, Middle Tennessee State University, Tennessee, USA
Hong Tran, University of Georgia, Georgia, USA

ABSTRACT
This symposium supports graduate students as they develop their research projects by providing an opportunity to present their works-in-progress and receive feedback from a symposium advisor and NARST attendees. The works-in-progress are emerging research undertaken by graduate students who have started collecting data or analysing the findings with support from NARST members.

PRESENTERS
Epistemic Tool use in Science Classrooms for Knowledge Generation: Role of Argumentation in Inquiry-based Instruction
Eric Antwi Akuoko, University of Iowa
Yes, and!" How improvisation and practice-based facilitation support facilitator confidence engaging diverse communities.
Amanda Andersen, University of California, Santa Barbara
Pre-Service Science Teachers Learning to Leverage Students' Thinking: Dilemmas in the Two-Worlds Pitfall
Ryan Coker, Florida State University
Paseos and Outdoor School. Developing Latina/o/x Families' interest and expertise about nature.
Diana Crespo Camacho, Oregon State University
Expanding scientific imagery and designs for science education through investigations of non-laboratory work
Bradley Davey, Northwestern University
Why Science? Purposes for Elementary Science Conveyed in State Academic Standards
Iliana De La Cruz, Texas A&M
Sensemaking Opportunities Provided by College Biochemistry Instructors
Desi, University of Minnesota
Applying Situativity Theory to Assess Urban and Rural Adolescents" Experiences at An Ag-Tech Summer Camp
Sarah Dodoo, University of Illinois, Urbana-Champagne
Challenges and Benefits of Offering CAT Vehicle Research Experiences for Undergraduates
Hannah Douglas, University of Arizona
Science Identity of Female Youth at a STEM Magnet School
Lilana Garcia, University of California, Santa Barbara
How do Informal Science Institutions portray Nature of Science and address cultural aspects?

Rachel Garcia, Patton College of Education, Ohio University
Ready OER Not: Engaging teachers with open education resources to create space for student identity
Emily Helton, West Virginia University
Investigating factors associated with nonscience major students" perceptions of credibility regarding publicly contentious science ideas
Benjamin Janney, Texas A&M
Understanding Elementary Preservice Teachers" Sensemaking About Responsive Teaching: A Vexation Focus
Ruveyde Kaya, Florida State University
Supporting Equitable Climate Change Decisions in Rural Contexts: Engaging critically with local data through co-design
Heather Killen, University of Maryland-College Park
Curricular customizations to desettle and problematize language use in science
Samuel Lee, Boston College
Queer in STEM: Exploration of experiences through an identity lens
Nelly Marosi, University of Groningen
Middle school Science teachers" support of student learning using Information and Communication Technology
Adjoa Mensah, University of Nevada, Las Vegas
Exploring Preservice Science Teachers' Expansiveness
Allison Metcalf, Florida State University
Using Social Network Analysis To Explore Collective Environmental Action and Environmental Learning
Aparajita Rajwade, North Carolina State University
Investigating the formal/informal science education binary at the K-12 level
Gerardo Sanchez Gutierrez, University of Texas-Austin
Justice-Centered Education for Sustainability in Secondary Environmental Science Classes
Chelsea Sexton, University of Georgia
Elementary Pre-service Teachers" Competence in Planning and Implementing Empathic Design in Cross-Cultural STEM Education
Soo Won Shim, Purdue University
"Some people are like the stars of the classroom, and others are like Pluto,Äù: Students" Experiences of Power, Status, and Care in An Elementary Science Classroom
Annabel Stoler, Boston University
Studying student engagement in active learning physics through the lens of epistemic (in)justice
Joineé Taylor, Florida International University
Equitable and Environmental Justice Oriented Modeling Experiences in Elementary Preservice Teacher Education
Lauren Wanger, Florida State University

Strand 1: Science Learning: Development of student understanding
Symposium: Learning Progressions in Science: What have we learnt and where next?
4/20/23, 13:10-14:40, Salon C7-8 (LL)

Learning Progressions in Science: What have we learnt and where next?

Linda Morell*, University of California, USA
Jonathan Osborne*, Stanford University, USA
Kristin Gunckel*, University of Arizona, USA
Richard Lehrer*, Vanderbilt University, USA
Mark Wilson*, University of California, USA
Alicia Alonzo*, Michigan State University, USA
Tiffany-Rose Sikorski, George Washington University, USA

ABSTRACT
Learning progressions emerged in the early 2000s from a mix of work on cognitive development and children's conceptions of science. They were proposed as empirically testable hypotheses of the stages of progression in children's learning of specific science concepts. As such they have been promoted as an evidence-based way of determining curriculum standards, instructional approaches, and appropriate assessments. In this symposium we seek to explore what have been their achievements to date, what the limitations are, and what might be further fruitful lines of research. To this end we bring together two presentations of current work – one exploring a learning progression for the cross-cutting theme of patterns, and another exploring a learning progression for data analysis. These presentations will illustrate the current nature of work, its methods and outcomes. Three individuals who have been key promoters or critics will then be invited to build on this work and give their reflections on the achievements to date and its limitations. Given the considerable investment in this research program over the past 17 years, we see this as a valuable opportunity to reflect and assess on the value of the work which will be of wide interest to NARST members.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set: Critical Pedagogies of Science and Technology
4/20/23, 13:10-14:40, Salon C5-6 (LL)

Building Community Agency through Participatory Tech Education

Sepehr Vakil*, Northwestern University, USA
Alisa Weith, Northwestern University, USA
Natalie Melo*, Northwestern University, USA

ABSTRACT
As educators and researchers committed to justice-centered computing education, we take seriously the responsibility to develop technology education in partnership with marginalized communities. In this article, we present a case study of the Young People's Race, Power, and

Technology Project (YPRPT), a program designed to engage Chicago youth in critical inquiry into the technologies impacting their local communities. Bringing together a citywide network of community partners–ranging from arts organizations to churches to after school groups–YPRPT cultivates and is anchored within mutually sustainable partnerships between our university research lab and the many communities alongside which we strive to design and build possibilities for youth learning. In this paper, drawing from our multi-year partnership with Family Matters Chicago (FMC), a community-based youth organization in the Rogers Park neighborhood of Chicago, we turn our gaze towards carefully examining the methods of our participatory work and the ways in which they cultivated the agency of our partners at FMC.

Seeking Truth Through Technology - Pre-Service Science Teachers' Political Use of Technology in Scientific Inquiry

Natalie De Lucca*, Vanderbilt University, USA
Jessica Watkins, Vanderbilt University, USA
Serena Pao, Vanderbilt University, USA

ABSTRACT

Following critiques of NGSS' framings of technology as neutral and apolitical (Gunckle & Tolbert, 2018; Rodriguez, 2015), a growing body of work examines how to support students in socio-politically explicit technological design (e.g., Tan & Calabrese Barton, 2018). The intentional design of engineering and technology learning can support youths to interrogate and reshape powered sociotechnical infrastructures. Our work is concerned with how political sociotechnical considerations emerged within scientific inquiry involving computer technologies, as students made sense of what counts as, and how to produce, "truth."

Middle Grades Students as Ethical World-Builders: The Cilantro Filter Engineering Challenge

Alejandra Frausto*, Northwestern University, USA

ABSTRACT

The NGSS represent one of the most widespread and proactive efforts to move engineering education into the elementary and middle grades. With this explicit shift towards integrating science with technology, engineering, and mathematics (STEM), K-8 teachers have an opportunity to avoid reproducing the pathologies of undergraduate STEM education. For example, there is evidence that college STEM students are less politically engaged and feel less social agency than their peers who study outside of STEM (Garibay, 2015). Engineering education too often teaches students to view built worlds as value-neutral problem spaces in need of engineered solutions wherein development is always positive and technology always marches forward. As we engage younger students more explicitly with engineering and technology, there are openings to encourage them to think about STEM in social contexts within which engineers design built worlds imbued with particular values and politics (Winner, 1980). This paper shares an engineering challenge for 6th grade students designed by their teacher to trouble notions of engineering as a set of acultural practices addressing apolitical problems.

The Promise and Pedagogy of Scientific Instruments for Linking NGSS with Teaching for Social Justice

Daniel Morales-Doyle*, University of Illinois Chicago, USA
Alejandra Frausto Aceves*, Northwestern University, USA
Mindy Chappell*, Portland State University, USA
Tiffany Childress Price*, University of Illinois Chicago, USA
Shelby Hatch*, Northwestern University, USA
Nina Hike*, University of Illinois Chicago, USA

ABSTRACT
La Colectiva (pseudonym) is a group of high school teachers, university-based scientists and science educators, community organizers, and youth working to support youth participatory action research (YPAR) projects in high school science classrooms. Previously, we identified challenges inherent in aligning YPAR projects about environmental racism with NGSS. Despite these challenges, we identified an opportunity in the expanded attention in the NGSS to teaching about technology. This paper uses a participatory design approach to examine the development of a series of laboratory activities intended to align YPAR projects about environmental racism with NGSS performance expectations through teaching about the functionality of scientific instruments.

Strand 4: Science Teaching - Middle and High School (Grades 5-12): Characteristics and Strategies
SC-Organized Paper Set: NGSS Implementation: Three-Dimensional Learning and Crosscutting Concepts
4/20/23, 13:10-14:40, Blvd A (L2)

An analysis of supports in OpenSciEd curriculum materials focused on use of the Crosscutting Concepts

Megan McLean, Washington State University, USA
Sarah Fick*, Washington State University, USA
Abraham Lo, BSCS Science Learning, USA

ABSTRACT
The Framework for K-12 Science (NRC, 2012) shifted teaching from being about science towards students making sense of their world using disciplinary core ideas (DCIs), science and engineering practices (SEPs), and crosscutting concepts (CCCs; the three dimensions). An important part of this work was that the CCCs needed to be made explicit to provide more equitable access to these tools. To learn to use the CCCs, students need support to understand how (Practical), and when and why (Epistemic) to use the CCCs. This study uses OpenSciEd curriculum materials as an example curriculum in which the CCCs have been intentionally included to describe how they are included and for whom that inclusion is explicit. The analysis uses three a priori coding schemes to understand how the CCCs are made explicit. Our findings show explicit references to the CCCs in every lesson, and almost all

CCCs were referenced. The supports were mostly practical, and most epistemic supports were explicit only to the teacher. That said, we recognize that few if any other curriculum materials are designing to include epistemic support for the CCCs as part of the learning process, but we also push for more.

Patterns in Conceptions of Crosscutting Concepts in Secondary Teachers

Sarah Fick*, Washington State University, USA
Chloe Dydasko, Washington State University, USA
Chad Gotch, Washington State University, USA
Kira Carbonneau, Washington State University, USA

ABSTRACT
Recent reforms in science education articulated shifts in how sensemaking processes are conceptualized. The crosscutting concepts (CCCs) became elevated to a dimension within the learning process that requires explicit attention. To make the CCCs explicit, teachers need to plan for how, when, and why, but little is known about how the teachers understand the CCCs as being useful for scientific sensemaking. This research describes how teachers, whose state science standards are the NGSS, understand the CCCs to be a part of their work of teaching. We interviewed five teachers for approximately an hour each to elicit their understanding of how the CCCs operate in science learning, and analyzed their responses using the descriptions of the CCCs from NGSS Appendix G. Our analysis yielded two important findings. First, teachers were able to articulate an understanding of almost all of the crosscutting concepts. Second, that teachers were likely to articulate depth of their understanding of one or two of the CCCs. This research provides important insights into how the CCCs are used by teachers and how they are aware of their use within their curriculum. The findings from this research can help support the design of curriculum materials and professional learning.

Integrating Scientific Investigations from Three Dimensions? Can We Specify What Goes in the Pedagogy?

Lin Zhang*, Providence College, USA
Zhushan Li, Boston College, USA
Jihang Chen, Boston College, USA

ABSTRACT
Between 2020 and 2022, a series of studies and reviews reported adverse effects from the policy-suggested ways of engaging students in investigation activities and raised an urgent call for looking closely into the ‘integration', particularly the ones suggested by NGSS. The present study compares high and low performing countries and examines how different they are in incorporating scientific investigation activities and science content knowledge in classroom teaching. The authors of this study will review these recently published controversial studies and share detailed concerns with teaching science through NGSS in hope of presenting a unique perspective to engage audience at the conference.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Faculty Knowlege and Beliefs about Instruction
4/20/23, 13:10-14:40, Astoria (L3)

Exploring the Relationship between Teacher Beliefs and Teacher Discourse Approaches in Undergraduate STEM Learning Environments
Abdi Warfa*, University of Minnesota, USA

ABSTRACT
Teachers' epistemic beliefs about knowledge influence their instructional decision making and provide mechanism for understanding classroom events such as discourse. In this study, we examined the relationship between teacher beliefs and discourse approaches in undergraduate STEM classrooms. Using an adaptation of Luft & Roehrig's Teacher Beliefs Index, we interviewed 13 faculty teaching introductory undergraduate biology. Our interview questions probed faculty's views about how students best learn biology concepts and revealed three instructor types: generative, instructive, and transitional. Generative instructors believed students learn best when they are challenged to generate reasoning and saw their role as mediating students' knowledge generation. Instructive teachers believed students learn best through passive approaches and tended to emphasize knowledge sharing. Transitional instructors were somewhere in between and tended to emphasize student-teacher relationships. When we examined the discourse patterns of our instructors using the Classroom Discourse Observation Protocol (CDOP), we found generative and transitional teachers used interactive authoritative and dialogic discourse while instructive teachers used solely non-interactive, authoritative discourse. Thus, the beliefs teachers expressed greatly influenced their discourse behavior even in active learning classrooms. We describe implications of our findings for advancing instructional change at the undergraduate level and understanding how STEM faculty leverage student thinking
Impacts of Perceived Leadership on Teacher Identity and Mediation of Student-Centered Practices in College STEM
Sule Aksoy*, Graduate Center, CUNY, USA

ABSTRACT
Existing research shows that environmental elements are essential in adopting reform-based teaching practices in postsecondary STEM. However, little attention has been afforded to the role of department-level leadership on teacher identity. Intending to fill this gap in the literature, the present study examined the relationship between leadership and teacher identity with the mediating effect of student-centered practices. A total of 135 postsecondary instructors participated in the study. Results showed that student-centered practices did not mediate the relationship between leadership and teacher identity. We also found that leadership did not significantly predict teacher identity. However, the mediation analysis revealed that student-centered practices significantly predict teacher identity. In other words, instructors who reported higher use of student-centered practices are likely to have a high sense of teacher identity. The findings imply that teaching practices are essential components of teacher identity formation for postsecondary STEM instructors. We expect our findings to help us better

understand the interplay between contextual factors, teaching practices, and teacher identity construction.

Characterizing PCK development among early-career undergraduate biology instructors

Alexander Waugh*, University of Georgia, USA
Tessa Andrews, University of Georgia, USA

ABSTRACT

Evidence-based teaching, such as active learning, requires knowledge beyond subject matter knowledge. Pedagogical content knowledge (PCK) is crucial to effective K12 instruction, and accumulating research also suggests an essential role for PCK in undergraduate teaching. Yet, we know little about how PCK develops. This study is the first longitudinal study of PCK development among biology undergraduate instructors and the most extensive study of PCK development conducted at any educational level. We interviewed 11 early-career undergraduate instructors before and after a video-recorded lesson and repeated data collection for every iteration of this lesson taught over the course of 3-5 years. We qualitatively analyzed knowledge elicited by these interviews and characterized variation in two PCK components and pedagogical knowledge. We also reduced the expansive dataset in order to make comparisons over time by developing rubrics. We observed PCK development for most participants. Participants developed PCK that was based on observations of student thinking, replacing assumptions and guesses about their students ideas' about lesson topics. Participants also developed PCK that was based on knowledge of student understanding, replacing knowledge that did not take student thinking into account. Preliminary findings suggest that pedagogical knowledge about monitoring student thinking can facilitate PCK development.

Faculty Development to Support Learning about Science Assessments: A Collaborative Self-Study

Lyndsay Munro*, University of Nevada, Reno, USA
Elizabeth de los Santos*, University of Nevada, Reno, USA

ABSTRACT

This study focuses on how collaboration between a science education professor and a chemistry professor supported their learning of assessment at the college level. Higher education faculty development is key for ensuring institutional quality and supporting institutional change. We used collaborative self-study to investigate how our ideas about teaching and learning at the college level changed as a result of engaging in research-practice partnership work with a local school district to develop high school chemistry assessments. We identified two critical activities that supported our learning: co-developing assessment tasks and soliciting student perceptions of having to explain their reasoning on assessment tasks. We share implications for higher education faculty development, particularly in light of the meso-level, or relations between professional learning and institutional culture and practices.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Beliefs/Perceptions about science teaching and learning across different contexts
4/20/23, 13:10-14:40, Salon A1 (LL)

Elementary Preservice Teachers' Beliefs about the NGSS Science Practices

Elsun Seung*, Indiana State University, USA
Vance Kite, North Carolina State University, USA
Soonhye Park, North Carolina State University, USA
Aeran Choi, Ewha Womans University, Korea, Republic of

ABSTRACT
This study explored elementary preservice teachers' beliefs about the importance and value of the NGSS science practices. An open-ended survey was used to collect quantitative and qualitative data from 83 preservice teachers. Quantitative data were analyzed for average ranking scores and frequencies to identify science practices that preservice teachers perceive to be the most important for student learning. Qualitative data were analyzed using qualitative content analysis to understand why and how the teachers valued each of the science practices. The expectancy-value theory (Wigfield & Eccles, 2000) served as both a theoretical and analytic framework for the study. Data analysis indicated that preservice teachers ranked Asking questions, Planning and carrying out investigations, and Analyzing and interpreting data as the top three most important science practices. In contrast, Obtaining, evaluating, and communicating information and Engaging in argument from evidence were ranked as least important. Preservice teachers attached attainment value most frequently to the scientific practices that they chose to be most important for science learning. The results of this study imply that preservice teachers have a limited understanding of the principles of NGSS, which intertwine science content learning and science practices under the umbrella of crosscutting concepts and the epistemic nature of science.

Exploring Changes in Pre-Service Science Teachers' Attitudes and Beliefs about Gender & Sexual Diversity-Inclusive Science Teaching

Gary Wright*, North Carolina State University, USA
Cesar Delgado, North Carolina State University, USA

ABSTRACT
Using a convergent mixed methods research design, this study collected quantitative and qualitative data to explore how pre-service science teachers' (PSSTs) attitudes and beliefs about gender and sexual diversity (GSD)-inclusive science teaching (GSDST) changed after participating in a GSD-infused intervention designed around a conceptual framework of teaching advocacy for queer youth and to explore which design elements of the intervention contributed to changes in their attitudes and beliefs. Results showed that the PSSTs were mostly supportive of measures indicative of GSDST prior to the intervention, and there was an overall trend in favor of GSDST with small to medium effect sizes after the intervention. The qualitative data revealed five design features of the intervention that contributed to the

observed changes: group dialogue; coherence to Ambitious Science Teaching; GSD terminology; knowledge of intersex, hormones, and LGBTQ scientists; and relevant case studies. This study highlights the need to understand how science teacher education program can impact PSSTs' attitudes, beliefs, and intended enactment of GSDST consistent with recent calls for GSD equity in science education.

Pre-service biology teachers' conceptions about what it means to understand biology: A phenomenographic study

Gregory Thomas*, The University of Alberta, Canada

ABSTRACT
The development of conceptual understanding is a long-standing goal of science education. However, a gap exists in the literature regarding what pre-service biology teachers' conceptions are of what it means to understand biology. Given the importance of teachers' epistemic conceptions for shaping their pedagogy, this gap is surprising. This study employed phenomenography to determine the qualitatively various ways that pre-service biology teachers conceptualize what it means to understand biology. Phenonemography is a second-order approach to research in which conceptions, are viewed as being the product of interactions between humans and the world around them, and arise from a human being's thinking about their external world. Sixteen pre-service biology teachers were interviewed individually for around thirty minutes each regarding their experiences as biology majors and their thoughts about what they considered it meant to understand biology. Five categories of description emerged from the analysis: (1) feeling, (2) applying, (3) making meaning, (4) communicating, and (5) accumulating. The first four categories occupy a higher level in the outcome space than the 'accumulating' category, as students reported that 'applying' and 'making meaning' were contingent on processes represented by the two sub-categories of 'accumulating.' The potential uses of these findings are suggested.

What matters?: Beginning secondary science teachers' perceptions of what influences their instructional practice

Matthew Wilsey*, Stanford University, USA

ABSTRACT
As teachers learn in and across multiple educational settings, determining which influences teachers perceive as meaningfully impacting their classroom instruction can help teacher educators and professional development providers design more engaging and effective learning opportunities. Drawing upon a sample of beginning secondary science teachers, graduates from the same teacher education program, this exploratory study investigated both teachers' perceptions of influences on their practice, as well as the perceived relative importance of the various instructional influences in order to understand how beginning teachers negotiate and organize multiple instructional influences. Findings indicate that teachers' perceptions of instructional influences varied, as they drew upon a wide range of influences. However, across the sample, personal teaching experience was deemed as the most influential factor for beginning teachers followed by teacher education experiences.

Implications for designing pre-service and in-service professional development for beginning teachers are discussed, as are avenues for future research.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Resiliency and Retention of Science Teachers
4/20/23, 13:10-14:40, Salon A3 (LL)

Inservice Elementary Teachers' Science and Engineering Teaching Self-Efficacy: A Synthesis of the Literature

Jeanna Wieselmann, Southern Methodist University, USA
Deepika Menon*, University of Nebraska - Lincoln, USA
Sarah Haines, Towson University, USA
Sumreen Asim, Indiana University Southeast, USA

ABSTRACT
Elementary teachers often have low self-efficacy for teaching science and engineering, and a range of professional development experiences have been designed to support teaching self-efficacy. Out of 117 total studies from 2010-2021 included in our systematic review, 22 focused specifically on inservice elementary teachers' science and engineering teaching self-efficacy. In this presentation, we synthesize this existing research to identify trends in the literature. Our findings reveal that while existing research suggests that professional development opportunities can support elementary teachers' science and engineering teaching self-efficacy, significant gaps in the literature remain. It is unclear why some professional development experiences support improved self-efficacy while others do not, and it is difficult to disentangle the effects of the many factors that may relate to self-efficacy within these studies. Recommendations for future research are described.

The case of new science teachers building up resilience in their early years of teaching.

Jose Pavez*, Western Illinois University, USA
Shannon Navy, Kent State University, USA
Julie Luft, University of Georgia, USA
Adepeju Prince, Kent State University, USA
Elizabeth Ayano, University of Georgia, USA
Kelly Kulp, University of Georgia, USA
Lisa Borgerling, Kent State University, USA
Bo Idsardi, Eastern Washington University, USA

ABSTRACT
Over the last few decades, teacher turnover has become a major concern across the globe. This is a concern because turnover often disproportionately affects students who are traditionally not well-served by their schools. Newly hired teachers are at high risk for turnover. Understanding the resilience of newly hired teachers may mitigate this turnover. Our study wanted to understand how newly hired science teachers reported their emotional, professional,

social, and motivational resilience. Four science teachers in their 1st and 3rd years of teaching completed surveys and interviews about their resilience over the course of a year. Our findings revealed that these newly hired science teachers had high levels of social resilience, and that 1st-year teachers exhibited higher levels of overall resilience than did their 3rd-year counterparts. The teachers also identified factors that contributed to and challenged their resilience, which included: in and out-of-school networks, mental health strategies, and technology and online resources. From this study, we suggest that induction programs and mentoring may contribute to the social dimension, which may be an central aspect of resilience. In addition, these teachers were losing their enthusiasm for teaching, which may contribute to their leaving the field.

The role of kinship in the retention of science teachers in Kingfisher School District

Suzanne Patzelt*, Montclair State University, USA
Douglas Larkin, Montclair State University, USA
Liz Carletta, Montclair State University, USA
Mayra Munoz, Montclair State University, USA

ABSTRACT
This case is drawn from a larger project designed to identify successful practices for supporting novice science teachers, with the aim of increasing retention. Our broad research question is: What is working in state and district efforts to retain science teachers? Our larger study is rooted in what is good and working in education, drawing on a theory of teacher embeddedness. In the first phase of research, we used publicly available data from 2007-2018 to construct a 5-year retention map for six cohorts of novice science teachers in four states. Second, we calculated the 5-year retention rate of newly hired science teachers in each cohort. The Kingfisher School District was initially identified for retaining 70% of its novice teachers within our study period, including a larger than average number of novice teachers of color, with many of the students, teachers, and administrators of Native American descent. We posit three factors that influenced the science teacher retention rate: (1) teachers' reasons for entering are the reasons for remaining and often for not teaching elsewhere, (2) the pull of home in Kingfisher County and the importance of kinship in the local Native American community, and 3) opportunities for professional growth and development.

Strand 8: In-service Science Teacher Education
Related Paper Set: Supporting teacher learning in integrated STEM Education
4/20/23, 13:10-14:40, Waldorf (L3)

Positioning teachers as active co-researchers examining PBL in STEM Education (Paper 1)

Kathleen (Kathy) Smith*, Monash University, Australia
Jennifer Mansfield*, Monash University, Australia
Amanda Berry*, Monash University, Australia
Peter Ellerton, University of Queensland, Australia
Nicoleta Maynard, Monash University, Australia

Deborah Corrigan, Monash University, Australia
Tabetha Spiteri, Monash University, Australia
Tim Smith, University of Queensland, Australia

ABSTRACT
This study brings together teachers and researchers to co-generate research-informed principles of practice for a Problem Based Learning (PBL) model of integrated STEM Education, and to embed these principles of practice into a coherent and sustainable pedagogical framework. The research is driven by a commitment to inquiry grounded in practice and to developing respectful and mutually trusting relationships between teachers and researchers. Teachers work as co-researchers, drawing from their expertise as they interrogate their practice to understand how key principles which define a PBL approach can be effectively translated into different school contexts. Actively positioning teachers as co-researchers challenges the expected roles of academic researchers and teachers and raises key considerations influencing choices at all stages of research design and knowledge production. When such considerations are effectively addressed, teachers think and work differently, clearly articulating the deep thinking driving their teaching, enabling the social construction of relevant and mutually valued professional knowledge. These findings create a new imperative for conceptualizing teachers as researchers producing collaborations which can enhance effective design and implementation of PBL in school-based integrated STEM education.

Using Design-Based Research as a Means to Build STEM Teacher Collaboration
Tamara Moore*, Purdue University, USA
Kristina Tank*, Iowa State University, USA
Selcen Guzey*, Purdue University, USA
Anne Ottenbreit-Leftwich, Indiana University, USA
Jennifer Kersten Olsen, Richfield High School, USA

ABSTRACT
Teachers have many demands on their time and often feel undervalued for their abilities to make sense of student understanding and curriculum choices. However, certain collaboration techniques help teachers feel valued beyond being a conduit to their students. Design-based research (DBR) is a research methodology for allowing researchers and teachers to co-design or collaborate to gather evidence for furthering understanding in the field. This paper provides different contexts for the use of DBR in engineering-based STEM integration studies and how this type of work supports teachers professionally and engages teachers in collaboration with researchers. We highlight data from three collaborations with teachers as co-designers/co-researchers that show the usefulness of DBR to engage teachers meaningfully in classroom interventions, student-level tasks for eliciting understanding, and a multi-level framework. The three cases demonstrate that teachers feel supported in their work and that the DBR experiences provide meaningful collaborations with the researchers. All three DBR studies produced meaningful artifacts that are useful to the field and provided the teachers with feelings of professional value and satisfaction, even across multiple types, scope, and scale of projects. This paper will contribute to the methodological understandings about DBR and how it supports teacher learning and collaborations.

A Study of Complex Curriculum Implementation Supported by a Comprehensive Professional Learning Plan

Janet Carlson*, CSET, Stanford University, USA
Rebecca Deutscher, CSET, Stanford University, USA

ABSTRACT
This study focuses on the professional learning support in an urban district on the west coast of the U.S. that was designed to support the implementation of a new curriculum for middle school science that included a problem-based learning approach, alignment with the Next Generation Science Standards (NGSS), integration of the 5E instructional model, and a focus on student agency in the classroom. District leadership worked with a university research center to design a professional learning approach that attended to this complex combination of curricular features and the high turnover rate of science teachers in this district. Our results showed positive trends with regard to changes in teacher practices as well as increased teacher agency as they adapted the curriculum to meet the needs of their students.

A complex collection of knowledges: the opportunities and challenges of preparing teachers for STEM education

Emma Stevenson*, The University of Melbourne, Australia

ABSTRACT
As science, technology, engineering, and mathematics (STEM) education has become more prolific in schools, teacher education programs have arisen to provide preparation for this interdisciplinary approach to teaching. Those designing STEM teacher education need to make decisions about what to include in the curriculum of programs. While research into STEM teacher education offers useful insight into the characteristics and impact of individual programs, there is limited discussion of why programs include specific curriculum features (e.g., knowledge areas, learning activities). Part of a larger qualitative, phenomenological study investigating the adoption of STEM teacher education at Australian universities, this paper focuses on one aspect of the research- what are the valued knowledge areas of STEM teacher education curriculum? Investigating multiple STEM teacher education curricula across thirteen universities, data was gathered from course coordinators, teacher educators and teachers through qualitative surveys and semi-structured interviews. The findings from this research highlight that a complex collection of knowledges is valued, however STEM teacher education curriculum decision making is context and participant dependent. Aiming to provide further insight into the possibilities for STEM teacher education curriculum, this paper explores the opportunities and challenges presented by each of these knowledge areas.

Exploring the Nature of Integrated STEM Throughout a STEM Curriculum Unit

Gillian Roehrig*, University of Minnesota, USA
Emily Dare*, Florida International University, USA
Joshua Ellis*, Florida International University, USA
Elizabeth Ring-Whalen, St. Catherine University, USA
Mark Rouelau, Michigan Technological University, USA

ABSTRACT
This presentation shares research that uses a new protocol designed for observing classrooms on which integrated K-12 STEM education is implemented. The 10-item valid and reliable instrument assesses the degree to which characteristics of integrated STEM are evident in an observed lesson. Specifically, this work explores questions related to how different lesson types may relate to different characteristics of integrated STEM education, comparing across individual items and across two dimensions previously established by principal component analysis: real-world problem solving and the nature of integrated STEM. In this work, we explored differences between lessons that are science-centric versus those that are engineering-centric. We examined protocol scores from over 2,000 elementary, middle, and high school classroom videos. Our analysis revealed that scores from engineering-centric lessons were statistically higher for all items in the real-world problem solving dimension and most items in the nature of integrated STEM dimension. However, science-centric lessons reveal higher scores for items relating content to students' lives and technology practices.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: How Teachers' Linguistic Beliefs and Practices Impact the Science Identities and Epistemic Agency of Multilingual Learners
4/20/23, 13:10-14:40, Salon A2 (LL)

Multilingual Identity: A Novel Intersectional Construct to Elucidate Students' STEM Experiences
Margaret Jeong*, University of Illinois at Chicago, USA
Roshni Bano*, University of Illinois at Chicago, USA
Minjung Ryu, University of Illinois at Chicago, USA

ABSTRACT
We sought to understand the unique experiences of multilingual undergraduate students in navigating STEM learning. To that end, we conducted an emergent qualitative study of interview data with 14 multilingual undergraduate students at an urban university. We posit that multilingual identity is a multidimensional, intersectional construct integrating language, race, ethnicity, first-generation status, and Muslim identity which profoundly influences students' relationships with their peers and professors. Our analysis that draws on this multilingual identity construct can guide efforts to propel multilingual students' success in STEM through improving instructional practices and valuing supportive peer relationships.

Multilingual Learners' Science Identities through the Lenses of Recognition, Funds of Knowledge, and Classroom Experience
Molly Staggs*, University of Florida, USA
Julie Brown*, University of Florida, USA

ABSTRACT
Pedagogy that cultivates students' science identity, or their ability to see themselves as capable of doing and understanding science, is particularly important for multilingual learners (MLs). Culturally responsive science teaching can provide an avenue through which teachers can affirm the science identities of MLs by incorporating students' cultural, language, and life experiences in their science instruction. This study used a descriptive multiple-case study approach to explore the science identities of six MLs whose biology teachers were enrolled in a professional development program to support their development of culturally and linguistically responsive instructional techniques. Analysis of student interview data revealed that students without STEM career aspirations still had a science identity outside of their career plans, while students with STEM career aspirations at times struggled to recognize themselves as scientists. All six students felt like scientists during hands-on laboratory activities, emphasizing the importance of classroom-based lab activities. This study has implications for the ways teachers' pedagogical choices and practices can influence ML's science identities in nuanced manners.

Customizing science curriculum for multilingual learners: Teachers' language beliefs and their customization decisions

Caitlin Fine*, Metropolitan State University of Denver, USA
Samuel Lee, Boston College, USA
Katherine McNeill*, Boston College, USA

ABSTRACT
Students bring to schools important ways of using language and multimodal semiotic tools (i.e. gestures, drawings) influenced by epistemologies from their homes and communities (Bang et al., 2017). Unfortunately, MLs often remain at a disadvantage because their linguistic and multimodal representations are not welcomed, acknowledged or leveraged for sensemaking in classrooms (García & Wei, 2017). Within this context, teachers' pedagogical decisions for ML sensemaking are often influenced by their beliefs about language and by their school language policy context (Zuniga et al., 2018). We addressed the following research questions: 1) What are teachers' beliefs about linguistic dimensions of science teaching and how do they relate to their school language policy? 2) How do teachers' beliefs about language for science relate to customizations they report making to OpenSciEd middle school science units for their ML students? We qualitatively describe how teachers' customizations related to their language beliefs and their school language policy across three theoretical buckets: language as problem, language as right/resource, language as dignity (Ruiz, 1984; Poza, 2021). Findings suggest that teachers across buckets may benefit from professional learning to develop customization practices centering MLs' linguistic resources as science sensemaking resources in their own right.

Making Space for Multilingual Student Epistemic Agency in Science Classrooms

Shakhnoza Kayumova*, Univeristy of Massachusetts Dartmouth, USA
Akira Harper*, University of Massachusetts Dartmouth, USA
Eleanor Richard, University of Massachusetts Dartmouth, USA

ABSTRACT
Within diverse US classrooms, for valuable science learning to be accessible for marginalized multilingual students, teachers must position students' cultural, linguistic, and identity repertoires as both valuable and legitimate assets. This has been shown to be challenging for teachers to do in practice. Therefore this paper investigates the teacher moves of two teachers who make space for multilingual student epistemic agency within their science classrooms. Specifically, this paper explores how two teachers use collaborative teaching practices within a multi-year longitudinal study of an inquiry-based summer STEM program to make space for the development of multilingual students' sense of epistemic agency within science classrooms.

Strand 11: Cultural, Social, and Gender Issues
Symposium: Centering a Conversation Around Approaches to Studying and Conceptualizing Teachers' Agency
4/20/23, 13:10-14:40, Salon C1-2 (LL)

Centering a Conversation Around Approaches to Studying and Conceptualizing Teachers' Agency

Alison Mercier*, University of Wyoming, USA
Anica Miller-Rushing*, University of Maine, USA
Felicia Moore Mensah, Teachers College, Columbia University, USA
Elizabeth Hufnagel, University of Maine, USA
Meena Balgopal, Colorado State University, USA
Jenny Martin, Australian Catholic University, Australia
Megan Bang, Northwestern University, USA
Carrie Tzou, University of Washington Bothell, USA
Leah Bricker, Spencer Foundation, USA
Jordan Sherry-Wagner, University of Washington Seattle, USA
Veronica McGowan, University of Washington Bothell, USA
Asli Sezen-Barrie, National Science Foundation, USA
Jennifer Lingle, University of North Carolina at Greensboro, USA

ABSTRACT
Teachers are considered one of the most important factors impacting students' learning and affecting the educational landscape. Their actions and decisions directly shape learning conditions for and outcomes of. Agency, or actions that contribute to the creation, re-creation, and transformation of educational structures and systems, is key to understanding teachers' decisions and actions. A better understanding and conceptualization of teachers' agency informs how to better support teachers as they navigate educational contexts. Even though agency is critical for understanding and supporting teachers, it remains an undertheorized and broadly conceptualized construct. This symposium brings multiple scholars and research groups together in conversation. Each presentation highlights a unique and diverse perspective

(e.g., the current state of the field, ethogenic approaches to exploring agency, quantitative measures of teachers' sense of agency, STEM teacher agency and curricular reform, teacher ecological agency, teachers' sense of agency while attending to uncertainty) and works to explore and bring clarity to the construct of teachers' agency when considering education research.

Strand 12: Technology for Teaching, Learning, and Research
Symposium: Distributing Epistemic Functions and Tasks – Towards a Methodological Approach for Using ML in Science Education
4/20/23, 13:10-14:40, PDR 2 (L3)

Distributing Epistemic Functions and Tasks – Towards a Methodological Approach for Using ML in Science Education

Marcus Kubsch*, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Christina Krist, University of Illinois at Urbana-Champaign, USA
Joshua Rosenberg, University of Tennessee, USA
Stefan Sorge, IPN – Leibniz Institute for Science and Mathematics Education, Germany
Peter Wulff, PH Heidelberg, Germany
Xiaoming Zhai, University of Georgia, USA
Ross Nehm, Stony Brook University, USA
Eugene Cox, University of Illinois Urbana-Champaign, USA
Barbara Hug, University of Illinois Urbana-Champaign, USA
Kevin Hall, University of Illinois Urbana-Champaign, USA
Elizabeth Dyer, University of Tennessee, USA

ABSTRACT
Machine learning (ML) is now a commonplace technology in our daily lives and in (science) education. However, the most visible applications of ML in science education research have focused upon developing systems for automated assessment. Teaching machines to replicate human behavior is potentially powerful. Doing so allows us to automate performances, such as the grading of student answers. While research focused on using ML in ways that automate existing performances can bring about a change in the quantity of the research efforts undertaken, it does not necessarily influence not their nature or quality. In other words, through automation-focused applications of ML, we gain more of the same kinds of insights. And yet this leaves a range of applications of ML unexplored, namely applications that aim at producing new insights.
We suggest that the current emphasis on using ML primarily to automate assessment is the consequence of the field currently lacking methodological frameworks for supporting creative, principled, and critical endeavors to use ML in science education research. We aim to offer one such framework–Distributing Epistemic Functions and Tasks (DEFT)–that can help us to expand our collective vision for how ML technology can be used in our field.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SC-Organized Paper Set: New Contexts for NOS Teaching and Learning
4/20/23, 13:10-14:40, Blvd C (L2)

Cognitive and Epistemic Account of Nature of Engineering: Implications for Science Education in Schools

Miri Barak*, Technion, Israel
Tamar Ginzburg, Technion, Israel
Sibel Erduran, University of Oxford, United Kingdom

ABSTRACT
Educators and policy makers advocate the need for developing students' understanding of the nature of engineering (NOE); yet, there is an ongoing debate on the heuristics that should be applied. Our goal was to propose a pedagogical framework for the conceptualization of NOE while drawing on aspects of nature of science (NOS). Based on policy reports and recent studies, this paper provides a theoretical ground for a conceptualization of NOE through the application of the Family Resemblance Approach (FRA). The FRA provided the theoretical and methodological 'anchor' for the pedagogical framing of NOE, focusing on cognitive and epistemic components. Accordingly, we describe NOE through four categories: Aims & Values, Engineering Practices, Methods & Methodological Rules, and Engineering Knowledge. For each category we provide examples of activities that can guide the teaching and learning about NOE. Our approach provides some nuance to the discussion about NOE conceptualization and application in school science education. As the year 2023 marks the anniversary of NGSS, our contribution lies in providing a theoretical and practical framing of NOE, with explicit references to the NGSS and other policy reports on engineering literacy in science education.

Development of chemical experiments for the explicit reflection of Nature of Science

Janne-Marie Bothor*, University of Kassel, Germany
David-Samuel Di Fuccia, University of Kassel, Germany

ABSTRACT
Experiments are often used in chemistry lessons to reproduce and illustrate existing scientific findings. Experiments in which learners are explicitly instructed to reflect on NoS also contribute to the promotion of Nature of Science (NoS). The study was conducted in a learning environment with the aim of imparting knowledge about NoS by designing chemical experiments based on an explicit reflection of NoS. In an open questionnaire with 20 participants, the ideas regarding the use of experiments in chemistry lessons were recorded. In addition, the participants created teaching material and explained the didactic concept of the implementation of NoS. The results of the pre-questionnaire show that the participants' ideas regarding the use of experiments mainly regard experiments as an instrument for knowledge reproduction and also as an instrument for learning Scientific Practices and for conveying the structure of the process of Scientific Inquiry and only rarely as an instrument for supporting NoS. The developed experiments show that the students often explicitly reflect the process of Scientific Inquiry instead of NoS and also design historical-problem-oriented settings.

E-VNOS: Analysis Framework for Characterizing Enacted Views of the Nature of Science in Student Theses

Annelies Pieterman-Bos*, University Medical Center Utrecht, Netherlands
Marc van Mil, University Medical Center Utrecht, Netherlands

ABSTRACT

The aim of this paper is to present the background, principles and procedures of a framework for qualitative analysis of student theses called Enacted Views of the Nature of Science (E-VNOS). E-VNOS is a descriptive and interpretative analysis framework based on several text analysis methods, discourse analysis, and reflexive thematic analysis. The procedure consists of the following, iterative phases: 1) analyze the structure, quality, and language of argumentation, 2) characterize discursive practices, 3) capture implicit VNOS enacted in the research article in codes, 4) generate initial E-VNOS motifs by identifying patterns in implicit E-VNOS, 5) develop and review E-VNOS motifs, 6) Refine, define, and name E-VNOS motifs. E-VNOS analysis results in two types of analytic outputs. First, an overview of discursive practices of the student, detailing how they use language to convey and construct their VNOS. Second, an overview of what VNOS the student enacts and what the nature is of their meaning-making around science and scientific knowledge. Similarities and differences comparing E-VNOS with other methods used for analyzing VNOS in Science Education research and with other qualitative analysis methods are discussed.

Examining Middle School Students' Nature of Science Views

Dilara Goren*, Bo_aziçi University, Turkey
Ebru Kaya, Bo_aziçi University, Turkey

ABSTRACT

This study examines middle school students' views on nature of science (NOS) with theoretical framework of the "Reconceptualized Family Resemblance Approach to Nature of Science (RFN)". Totally 12 middle school students from 5th, 6th, 7th and 8th grade level participated to the study. The data was collected through semi-structured interviews and analysed with thematic analysis (Braun & Clark, 2006). The results show that most students have some problems in viewing science as epistemic-cognitive–social system holistically. The students' ideas were mainly focused on social components of science. They were able to explain the professional activities, scientific ethos, social values, social organizations and institutions, political effects. For aims and values, the students focused on serving to humanity, making developments, informing people. Most students viewed scientific practices and methods as same principles and they have limited views about laws and theories, and the scientists' work in generating scientific knowledge. The higher grade level (7th, 8th) students' ideas were more detailed and elaborated than the 5th graders. It can be suggested that each category of RFN can be integrated in science curriculum and students can learn these epistemic-cognitive-social components of science.

Strand 14: Environmental Education and Sustainability
Related Paper Set: Promoting Socio-ecological Caring Practices in Science Education: Models, Possibilities, and Complexities
4/20/23, 13:10-14:40, Salon C3-4 (LL)

Restorying Nature-Culture Relations Towards Multispecies Ecological Caring Across Scales of Implementation

Philip Bell*, University of Washington, USA
Nancy Price, University of Washington, USA

ABSTRACT
In this age of acute climate crisis and environmental degradation with its disproportionate impacts, there is a growing awareness that we need to broadly disrupt anthropocentric and extractive logics in human-nature relations. This will necessitate figuring out how to promote onto-epistemic transformation of public understanding centered on multispecies caring and human-nature relationality grounded in ethico-political responsibilities of interdependence and collective continuance. A key strategy for reaching a broad scale is to shape the formal school science curriculum used as part of educational standards implementation efforts—along with aligned professional learning and assessment infrastructures. This design-based research across two elementary classrooms is part of a state-level network improvement community engaged in a loosely coordinated educational standards implementation project focused on climate science education. In this paper, we trace linkages between scales of implementation by relating the design of specific learning environments with classes of elementary students with the capacity building and infrastructuring of the distributed, state-level network improvement community. We present findings about how local educational transformation can be generatively shaped by and can shape broad scale implementation initiatives with the goal of shaping local transformation elsewhere.

How children engage in just worlding through multispecies design and radical care in engineering education

Anastasia Sanchez*, University of Washington, USA

ABSTRACT
The influence of NGSS, the NRC Framework for K-12 Science Education, and a socio-workforce push to increase diverse representation in STEM fields, engineering education has become more prevalent in K-12 classrooms over the past decade. Despite this optimistic shift, engineering research and learning tends to be conformational and positivistic through the adherence to a closed, systematic design process, decontextualized from high-stakes socio-political and socio-ecological realities. Learning and research that is situated within the confines of normative engineering learning fails to nurture and cultivate students' intellectual health and ontological security and further promotes harmful settler eco-logics. By examining students' ways of understanding engineering as deeply connected to consequential socio-ecological concerns and the radical care of disenfranchised communities, multispecies and landsairwaterstars this study was able to capture students' radical ways of caring in engineering practices that exceed the parameters of mainstream implementation of NGSS

educational and research standards, suggesting not only what is possible in classrooms engaging in curriculum reform but provides a trajectory for how science and engineering education should be conducted in keeping with values of relationality and critical response-ability for a flourishing otherwise.

Socio-ecological Minding: Examining methodological conundrums & neglected narratives with youth

Kelsie Fowler*, University of Washington, USA

ABSTRACT

In this paper I suggest that to grow students' responsibility and relationality toward their communities (humans and beyond), requires science educators and research partners to intentionally design learning opportunities, specifically inquiries, to incorporate moments of what I call "Socio-ecological Minding"—or pauses to critically narrate science learning and research. To do this, I build upon Socio-ecological Care, arguing that research and inquiry processesspecifically should undergo rigorous evaluation for effects of personal or group actions. Using a critical participatory ethnographic approach, I followed an iterative thematic coding process to analyze 404 data sources. The findings weave together dialogue, interview data, field logs, and other artifacts to feature themes of how research members of a youth-led plastics' study in Mexico narrated their own learning and research in terms of multispecies community and environmental justice. Results indicate that while some of these tensions, "conundrums", were discussed, most consequential concerns remained as "neglected narratives"—never problematized or discussed. Additionally, the findings suggest that critical readings of doing science can elicit connections and new ways of being that reach far beyond a specific experiment or project. Socio-ecological Minding can foster novel ways of reflecting upon human actions and relationships in, and with, this world.

Can there be a science of the sacred?

Sara Tolbert*, University of Canterbury, New Zealand

ABSTRACT

In this paper, using string figuring as a method for weaving connections across contexts, places, and time (Haraway, 2016), I draw from two sources, (1) an audio-recorded and transcribed focus group of high school students discussing a cat dissection activity, and (2) a published and publicly available online video vignette of children in a kura kaupapa M_ori (M_ori medium school) negotiating their ethical responsibilities and cultural conflicts in dealing with the euthanization of individual moths (in their creation of a reference collection to monitor/ protect the species as part of a citizen science project). I identify both connections and differences across these two stories of caring to articulate how students' own concerns for more-than-human in science activities, in both settings, serve as a generative object for contemplating ceremonial/ritual practices in science education as care among human and more-than-human relations.

Poster Session A
4/20/23, 14:50-15:35, Grand Ballroom (L2)

Strand 1: Science Learning: Development of student understanding

On Critiques to Learning Progression Research

Hui Jin*, Georgia Southern University, USA

ABSTRACT

Although the LP research has generated important findings and products, it faces major critiques. Researchers have questioned how a sequence of achievement levels can be used to present dynamic and complex learning of students and how a single LP can be used to present the development of many different students; without a sound theoretical rationale, how can the empirical validation of LPs be meaningful (Shavelson & Kurpius, 2012; Sikorski & Hammer, 2010). Up to date, these critiques have not been adequately addressed. To respond to these critiques, this presentation answers two questions: 1) Can students' understanding of a scientific idea or practice be presented as a small number of achievement levels? 2) Is it appropriate to order those achievement levels into a learning progression? More specifically, theoretical ideas and empirical evidence from science education, developmental psychology, and cognitive linguistics are used to answer the questions. Many NARST participants would be interested in this discussion.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Understanding Science Texts is Specific: Cognitive and Motivational Characteristics as Predictors of Students' Text Comprehension

Hendrik Härtig*, University of Duisburg-Essen, Germany
Nadine Cruz Neri, University of Hamburg, Germany
Sascha Bernholt, Leibniz Institute for Science and Mathematics Education - IPN, Germany
Anke Schmitz, Leuphana University, Germany
Jan Retelsdorf, University of Hamburg, Germany

ABSTRACT

When learning, students often must comprehend different types of expository and narrative texts which is affected by a complex set of variables which predict students' text comprehension. It can be assumed that some of the effects of specific student characteristics on comprehension depend on the text genre, e.g. science. However, studies often do not explicitly investigate if student characteristics affect comprehension depending on text genre. In a former study, we used the direct and inferential mediation model (Cromley & Azevedo, 2007) to explain and compare predictors of text comprehension of science and narrative texts and found a general comparability but also some differences. In the present study, we go beyond measuring cognitive variables by including motivational variables and controlling for demographic and sociocultural background comparing threes science and one narrative text. Path modeling revealed that the generation of inferences and vocabulary knowledge were significant predictors of text comprehension in general. Reading strategy knowledge predicted

text comprehension of a narrative and partially science texts, while reading for interest predicted text comprehension only in two of three science texts. Identifying domain-general and domain-specific characteristics of text comprehension can enable teachers to foster students' text comprehension.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Research on Embedded Engineering Education in Science Settings (2011-2021)

Allison Antink-Meyer*, Illinois State University, USA
Melisa Brown, Illinois State University, USA
Margaret Parker, Illinois State University, USA
Jennifer Smith, Illinois State University, USA
Mike Jones, Illinois State University, USA
Ryan Brown, Illinois State University, USA

ABSTRACT
This systematic review (Alexander, 2020) of research on embedded engineering education in science settings addresses the question of what scholars in science education have prioritized in the first decade of the inclusion of engineering education within school science. Given the differences in how engineering is framed as coming alongside science in the NGSS and how engineering literacy is framed by the ASEE Framework we see value in exploring what scholars have sought to uncover about the ways that engineering and science have become interwoven since the release of the Framework (NRC, 2012). This poster will include descriptions and evidence of two sets of themes that address the critical question: what themes related to the incorporation of engineering within science have emerged in science education research? The preponderance of each theme across the dataset and journals will also be shared. Understanding how the scholarly field of science education has approached learning about embedded engineering education in science learning settings will expose opportunities for integrating findings and for understanding gaps.

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

Elementary Daily Schedules: Comprehensiveness, Frequency, and Consistency of Science

Elizabeth Davis*, University of Michigan, USA
Christa Haverly, Northwesteren University, USA

ABSTRACT
Science in the elementary grades is often deprioritized in comparison to ELA and mathematics. Yet a recent National Academies of Sciences, Engineering, and Medicine report recommended that science be included in elementary schedules in ways that are comprehensive, frequent, and consistent (NASEM, 2022). In this study, we reviewed daily schedules for 12 schools across the U.S. to qualitatively examine how science is represented on the daily instructional schedule. These schools were selected as "best case scenarios" recommended by district or state science leaders as places where science is taken seriously. We complement these schedule data with data from interviews with teachers, science specialists, and school leaders to better understand how science actually appears in children's daily instructional experiences. Our findings suggest that, in these schools, science is taught comprehensively (though not as

comprehensively as ELA or mathematics), has the potential for being taught frequently (even in the lower elementary grades), and is taught somewhat consistently (albeit usually in some kind of rotation with social studies). The paper closes with implications for both how school schedules could be crafted to make science comprehensive, frequent, and consistent, as well as some pitfalls that could be avoided as schedules are developed.

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

Representations of Astronomy in Children's Picture Books

Julia Plummer*, The Pennsylvania State University, USA
Alison Allen, Rockman et al Cooperative, USA

ABSTRACT

This study examines how astronomy is portrayed in children's picture books, selected from notable book lists, published between 2001-2021. Selected books (N=32) were analyzed in terms of how they portray the practices of science, using the Next Generation Science Standards as a framework. We also analyzed the gender, age, and race of main characters. Few books among the selection portrayed characters engaged in scientific investigation, either throughout (3) or during part of the narrative (4). Science practices appeared in 14 of the select books, but this was primarily the practice of asking questions. The main characters were close to evenly split between male (13) and female (16), and most main characters were children (25). When the selection of books from Diverse Book Finder (10) was included, the racial back ground of human main characters was close to even between white (9) and Persons of Color (13). However, without that portion of the sample, the selection is less diverse (9 to 6). Currently, astronomy picture books provide limited support for the NGSS, in terms of how they convey science practices, and teachers may have difficulty locating books that portray diverse characters engaged in astronomy.

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

My "go-to" person: Social networks and teaching practice in an elementary science professional learning program

Peter Bjorklund, University of California at San Diego, USA
Bridget Murray, American Museum of Natural History, USA
Jenny Ingber, American Museum of Natural History, USA
Colleen Owen, American Museum of Natural History, USA
Hudson Roditi, American Museum of Natural History, USA
Shannon Haas, New York Botanical Garden, USA
Barbara Kurland, Brooklyn Botanic Garden, USA
Marnie Rackmill, Queens Botanical Garden, USA
Lauren Tecosky, American Museum of Natural History, USA
Anna MacPherson, American Museum of Natural History, USA

ABSTRACT

Implementing the Next Generation Science Standards (NGSS Lead States, 2013) in elementary school classrooms demands that teachers rethink their own science learning experiences, attitudes, and knowledge to develop instruction that incorporates investigation of phenomena

and engagement with scientific and engineering practices. The program that is the subject of research is a partnership between an urban school district and cultural institutions, including science museums, zoos, and gardens. In addition to having research-based features and using NGSS-aligned tools, the program aims to develop a professional network. We designed, piloted, and distributed a survey that asked participants about who they relied upon for information and resources; we used these items to analyze the social network structure within the program. We also collected data about self-reported NGSS-aligned teaching practice. We found that although teachers in the program had, on average, one "Close Relationship" in the program, the social network was diffuse, with many isolates and disconnected clusters. We hypothesize that implementing structures to encourage social networking may enhance the connections between teachers and facilitate the sharing of information and practices. Given the challenge of shifting instructional practice, strengthening ties within the program (and in professional learning networks, in general) may be a promising strategy.

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

The Burning Matter: Investigating Data Representations in Wildfire Learning

Brandin Conrath*, The Pennsylvania State University, USA
Scott McDonald, The Pennsylvania State University, USA
Amy Farris, The Pennsylvania State University, USA
Amy Pallant, The Concord Consortium, USA

ABSTRACT

With respect to a changing landscape of geoscience learning to support learners in understanding Earth's climate, there has been a growing interest in engaging science learners with and around climate data. Often, data is incorporated into classrooms to support student explanations through the use of data representations. However, data representations do not lead directly to explanations. In this study, we examine the interactions and discourse of a middle school science classroom as they engage with data representations of wildfire related information. Preliminary findings demonstrate that learning with data representations requires skills and practices of data literacies. Students were required to interpret and critically analyze data representations to make claims and predictions of wildfire risk. Making sense of data representations challenged students. Specifically, students grappled with the uncertainty of varying temporal data and reasoning across different data representations. Their attempts to interpret and analyze the data serves as a basis to develop their own data literacies. However, these literacies are often underdeveloped and require support from more data-literate teachers. Teachers need to support students' critical interpretation of data representations so they can independently make informed climate decisions.

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

Draw an Earth Scientist: Investigating Undergraduate Students' Conceptions of Earth Scientists

Deef Al Shorman*, University of Nebraska-Lincoln, USA
Deepika Menon*, University of Nebraska-Lincoln, USA
Peggy McNeal, Towson University, USA
Paulina Schaefer, Towson University, USA

ABSTRACT
This study aims to investigate undergraduate students' (N = 94) conceptions of Earth scientists during their participation in introductory Earth science courses at two large public universities in the United States. Drawing on the theory of contextualization, the study utilized drawings as a tool to understand undergraduate students' conceptions of Earth scientists. The research is guided by the following questions: (1) What student conceptions are evident in undergraduate students' drawings of Earth scientists? (2) How do undergraduate students' conceptions of Earth scientists—as evidenced in their drawings—change as a result of completing an introductory Earth science course? Data sources include pre-and post-course administrations of the Draw an Earth Scientist Test (DAEST) and an open-ended questionnaire. The data analysis included a Chi-square goodness-of-fit test analysis, which was used to see if there was a significant difference between the pre and post-drawings for each subcategory: physical appearance, location, activity/position, instrument/tools, and objects for study. The average Cohen-Kappa coefficients for the five categories were calculated for the inter-coder reliability and came out at 0.820. The results indicated statistically significant shifts in participants' conceptions of Earth scientists in subcategories such as lab coat, celestial bodies, and clouds/weather/atmosphere.

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

Interdisciplinary Science and Converging Identities: Minority Graduate Student Experiences in Convergence Settings

Kathleen Bordewieck*, North Carolina State University, USA
M Gail Jones, North Carolina State University, USA

ABSTRACT
This case study explored graduate students' experiences conducting interdisciplinary research in a large convergence science center. Eight student participants were followed for an academic year as the students engaged in convergent research focused on phosphate sustainability. Students were interviewed quarterly to document expectancy value factors such as experiences, perceptions of others, academic identity, achievement task value, self-efficacy, costs, and future task value. The analyses showed that student's identity as a scientist in their discipline is affirmed in convergence settings. Convergent research and epistemic humility ameliorated some of the challenges of interdisciplinarity by providing an open environment with a shared goal to motivate students. This shared goal supported students even when they experienced daily stressors related to their minority status.

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

Course-based undergraduate research experiences (CUREs) to advance science communication (SciComm) skills: A systematic review

Ebenezer Korkor*, Illinois State University, USA
Rebekka Darner, Illinois State University, USA

ABSTRACT
In this study, we performed a systematic literature review using review methods outlined by Bearman et al. (2012) to understand how course-based undergraduate research experiences (CUREs) might foster scientific communication (SciComm) skills. First, we explored the pedagogical strategies used in developing SciComm skills in undergraduates. Subsequently, we examined the literature on pedagogical strategies used in the implementation of CUREs, and then we did a comparative analysis to decipher points of intersection among pedagogical strategies used in CUREs and to foster science communication. Analyses of the science communication literature revealed that blogging and infographic activities, analyzing data, analyzing scientific literature, increasing exposure to writing contexts, providing multiple opportunities to present findings either orally or in written form, and providing feedback support the development of SciComm skills. Though these instructional strategies used in fostering SciComm skills among undergraduates have been successfully utilized in one or more CUREs, they are underutilized. To harness the impact of CUREs, its implementation should be coupled with more explicit SciComm skill development and assessment, particularly regarding communication with lay audiences, which would better prepare students for the workplace, graduate school, and most importantly, as change agents in society. This study concludes with recommendations for future research.

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

Departmental fit impacts adoption of evidence-based practices in STEM classes for Tenure and Non-Tenure Professors

Trisha Douin*, University of Louisville, USA
Raymond Chastain, University of Louisville, USA
Marci DeCaro, University of Louisville, USA
Jeffrey Hieb, University of Louisville, USA
Linda Fuselier, University of Louisville, USA

ABSTRACT
Evidence in support of student-centered learning strategies is well established. However, faculty face structural and cultural barriers to implementing these strategies within Science, Technology, Engineering, and Math (STEM) teaching practices. To measure the degree of engagement with and use of evidence-based practice (EBP) in teaching, we utilized a mixed-methods approach, utilizing interviews, surveys, and observational data. Interviews with college instructors across four science disciplines and department chairs revealed that Non-Tenure Track (NTT) faculty lack autonomy and feel undervalued in the department. However, interviews with Department Chairs revealed a disconnect between department concerns and the concerns of NTT faculty. Interestingly, teaching practices employed by NTT faculty were more student-centered than those used by tenure-track (TT) faculty. Both barriers and levers to the adoption of EBP were enmeshed in a combination of personal beliefs and institutional obstacles. Factors encouraging and discouraging the use of EBP in science classrooms differed for instructors depending on their tenure or non-tenure status, and this superseded compensation. As a result of a perceived lack of value and autonomy, NTT faculty have an identity different from TT faculty, even though both employ EBP in their classes, and the perception of the department chair may scaffold this identity construct.

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

General Chemistry Students' Language Fluency in the Context of a Precipitation Reaction

James Nyachwaya*, North Dakota State University, USA
Teri Tran, Georgia State University, USA
Tarah Dahl, West Fargo High School, USA
Krystal Grieger, North Dakota State University, USA

ABSTRACT

This study sought to examine college general chemistry students' understanding and use of academic language in the context of a precipitation reaction. During an in-class activity, students working in groups of 3 or 4 were shown a video of a precipitation reaction and asked to note and record their observations. They were asked to predict the products of the reaction, write a molecular and ionic equations, predict how electrical conductivity of the reacting mixture, starting with one of the solutions, and then draw a sketch of their prediction. Our results show that students struggled to invoke context-appropriate vocabulary such as ‘precipitate' in describing observations, and at times used inappropriate vocabulary. Some groups struggled to correctly name compounds and ions from formulas. We found instances where students used colloquial language instead of context specific technical language. Results also show that some student groups struggled to interpret and translate instructions about their sketches of electrical conductivity. Specifically, some groups switched axes labels (from the instructions) while others either used wrong labels or did not include labels in their sketches, showing that they did not interpret the language in the instructions. These results have implications for the teaching, learning, and assessment of science.

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

Faculty and Graduate Student Perspectives on STEM Undergraduate Education

Veronika Rozhenkova*, University of California, Irvine, USA
Elizabeth Park, Westat, USA
Brian Sato, University of California, Irvine, USA

ABSTRACT

It is well-documented that STEM programs suffer from what is known as a "chilly" climate that impedes the success of certain minoritized groups of students. Drawing from the survey data collected at a research-intensive, minority-serving institution, this study aimed to explore the differences in STEM faculty and graduate student perspectives on undergraduate education. Based on the generational replacement theory, we hypothesized that graduate students would show patterns of generational changes and exhibit higher levels of understanding of the value of practices that support equity in the classroom as well as the role of diversity in the curriculum. Our findings revealed that graduate students and faculty have similar opinions on the instructional approaches related to diversity in the STEM classroom with students believing even more that diversity did not have a space in the curriculum relative to faculty. Graduate students are less likely to agree that racial and ethnic diversity should be more reflected in the curriculum. We argue that institutions, which may have been expecting that the next generation of STEM leaders would usher in a more diverse classroom climate, instead need to re-evaluate

current and future practices and policies regarding faculty professional development to create a more inclusive environment.

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

Learning from Peers: Patterns of Talk and Metacognition in a Peer Learning Assistant-supported Biology Course

Brittney Ferrari*, University of Georgia, USA
Masha Kurbatova, Bard College, USA
Julie Kittleson, University of Georgia, USA

ABSTRACT

Metacognition, or thinking about one's thinking, is essential for building conceptual understanding as it actively engages students in reflection and sense making. However, development of metacognitive awareness and strategies to regulate learning can be challenging without instructor prompting. Although it can be difficult to implement active learning in large science courses, increasing instructional support with Peer Learning Assistants (PLAs) offers opportunities for promoting student collaboration and metacognition. PLAs are peer tutors that are pedagogically trained to support student learning by facilitating interactive discussions that elicit, question, and guide student thinking in class. To investigate how PLAs support student learning and metacognitive development, we applied a discourse analysis approach to audio recordings of group work in an undergraduate biology course. Our analysis focused on both turn-taking and metacognitive patterns within PLA-student interactions to examine how PLAs organize turns and prompt student use of metacognitive strategies during group work. We found that PLAs utilize pedagogical training to guide their interactions with students and we identified several prompts that promote metacognition. Students used monitoring and evaluating metacognitive strategies to regulate their learning while interacting with PLAs during group work, suggesting that PLAs can effectively foster students' metacognitive development and support student learning.

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

Becoming a Field Biologist: Perspectives of Mentors and Undergraduate Researchers in a Summer REU Program

Stephen Burgin*, University of Arkansas, USA
Zephaniah Greenwell, 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 in a biological sciences laboratory. Two undergraduate students from an underserved population worked with one faculty member, one post-doc, and two graduate students both in the laboratory and out in the field, to study the transmission of conjunctivitis in populations of captive finches and in wild mountain bluebirds. 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. Recommendations for Research Experiences for Undergraduate students are suggested that

we hope policy makers and faculty who host undergraduate students in their laboratory groups will attend to.

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

Re-designing Infrastructure to Implement Active Learning in Undergraduate Chemistry

Jonathan Hall*, California State University, San Bernardino, USA
Lisa Lundgren*, Utah State University, USA
Todd Campbell*, University of Connecticut, USA

ABSTRACT

This case study reports on the educational infrastructure of chemistry faculty and student leaders who re-designed introductory chemistry courses to facilitate active learning experiences. In an attempt to move away from traditional, lecture-style instruction, colleges have started to implement active learning pedagogy. Active learning, which incorporates collaborative assignments that facilitate higher-order thinking, has been shown to be an effective learning strategy. Educational infrastructure (e.g., relationships and materials) rarely gains the attention of science educators until problems arise or changes are needed. Surfacing educational infrastructure supports educational change by analyzing underlying mechanisms that structure the implementation of the curriculum. Qualitative cases for chemistry faculty and student leaders were based on participant interviews, classroom observations, and analysis of curriculum materials. Findings show that the work on infrastructure re-design for chemistry faculty and student leaders involved developing pedagogical knowledge about how active learning can be implemented and necessitated collaborative work in these efforts. Additionally, collegial workspaces and dedicated times for collaboration for all participants to share their experiences, challenges, and needs were beneficial for establishing and moving forward the work of the chemistry faculty and student leaders.

Strand 6: Science Learning in Informal Contexts

Museum Facilitators of VR Experiences for Middle School Students Approach Constructivist Pedagogy

Leah Metcalf*, The University of North Carolina at Chapel Hill, USA
Janice Anderson, The University of North Carolina at Chapel Hill, USA
Jill Hamm, The University of North Carolina at Chapel Hill, USA

ABSTRACT

Application of adequate learning supports have been found to correlate with students learning science from educational virtual reality (VR) experiences. An investigation of features of VR facilitation, which is a common and potentially important VR support, in a physics exhibit for middle school students that features the work of scientists from underrepresented backgrounds, was conducted. Video data were transcribed, coded and analyzed using inductive, qualitative analysis to support the advancement of substantive themes. Facilitators were found to deepen student discussion through moves that were suggestive of constructivist pedagogy. A framework of facilitation that is an expansion of moves uncovered during this analysis potentially will be created during subsequent study of a larger dataset.

Strand 6: Science Learning in Informal Contexts

Discoveries in Earth science for students with blind and visual impairments

Rhea Miles*, East Carolina University, USA
Alana Zambone, East Carolina University, USA
Alex Manda, East Carolina University, USA
Margaret Blome, East Carolina University, USA

ABSTRACT

Students with Blindness or Visual Impairments (BVI) can be successful in conducting scientific investigations to address state and Next Generation Science Standards (NGSS). The Discoveries in Earth Science program (DES) provides engaging experiences to increase competency/knowledge and performance skills to address the needs of elementary, middle and high school grade students with (BVI) to prepare for careers in STEM. This preliminary study focuses on how this informal science program addresses program goals and research questions.

Strand 6: Science Learning in Informal Contexts

Success of Gender-Based STEM Summer Camps: Co-Ed vs Same-Gender

Miriam Sanders*, Texas A&M University, USA
Niyazi Erdogan*, Texas A&M University, USA
Julia Calabrese, Texas A&M University, USA
Mary Capraro, Texas A&M University, USA

ABSTRACT

Existing research shows informal STEM learning experiences such as after-school programs and summer camps present promising avenues for strengthening female students' STEM self-concept. We seek to examine the moderating effects of female students' enrollment (co-ed or same-gender STEM camps) on the relationship between female students' perceptions of mathematics and interest in other STEM subjects. Our findings showed that middle grade students with higher mathematical self-efficacy demonstrated statistically significantly higher knowledge of STEM careers, as participants in our study with higher mathematics perceptions demonstrated higher interest in other STEM subjects. Additionally, our results did not indicate that camp type (co-ed or same-gender) influenced female students' interest in STEM subjects.

Strand 6: Science Learning in Informal Contexts

Towards more individualized support in science competitions: Profiles of participants in the Physics Olympiad

Paul Tschisgale*, Leibniz Institute for Science and Mathematics Education, Germany
Anneke Steegh, Leibniz Institute for Science and Mathematics Education, Germany
Marcus Kubsch, Leibniz Institute for Science and Mathematics Education, Germany
Stefan Petersen, Leibniz Institute for Science and Mathematics Education, Germany
Knut Neumann, Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
Science competitions are traditional informal learning activities that aim to foster participants' abilities and arouse science interest and long-term engagement in all participating students. In order for science competitions to achieve these goals, they must be designed to meet the needs of each participant based on individual characteristics. Therefore, it is necessary to understand how participants can be characterized based on their cognitive and affective traits. However, little research exists on this matter to date. The present study therefore aimed to characterize participating students at the start of the German Physics Olympiad – a prototypical task-based science competition – based on cognitive (domain-specific and general cognitive abilities) and affective characteristics (physics interest, physics self-efficacy, grit). We employed latent profile analyses to identify profiles among N = 155 participants and related profile membership to success in the competition and physics career motivation. We identified four substantially different participant profiles distinguished by specific patterns in cognitive abilities, interests, and self-efficacies. Moreover, we found significant differences across profiles regarding participants' success in the competition and physics career motivation. We discuss implications of our findings for more individualized support in science competitions based on participants' needs in terms of favourable transitions between profiles.

Strand 6: Science Learning in Informal Contexts

Studying Floor Facilitator Conversations in a Natural History Museum

Preeti Gupta*, American Museum of Natural History, USA
Rachel Chaffee*, American Museum of Natural History, USA
Kevin Crowley, University of Pittsburgh, USA
Karen Knutson, University of Pittsburgh, USA
Abby Perez, American Museum of Natural History, USA

ABSTRACT
Facilitator conversations with families in collections-based informal science institutions are important activities to study because it helps practitioners and researchers deepen their understanding of how audiences are making meaning of the exhibits and the role that facilitated conversations play in fostering those conversations. This study builds on existing knowledge of family conversations and focuses on the facilitator, in this case, college-aged youth who are taught to have these conversations through a comprehensive training program. The research inquiry is a) what facilitator moves and engagement strategies do youth facilitators deploy to create conversation with visitors? And b) in what ways do different types of youth facilitators mediate the trajectory of the conversation based on their unique styles and characteristics? We present details about the training, findings from surveys coupled with 72 videotaped conversations and we discuss implications for further research and for practitioners working in such institutions.

Strand 7: Pre-service Science Teacher Education

"But what can I do?": Science Teaching for Racial and Environmental Justice

Jenny Tilsen*, University of Minnesota, USA
Stefanie Marshall*, University of Minnesota, USA

ABSTRACT
This study examines the pedagogical decision making and curricular modifications made by pre-service teachers (PSTs) as they adapt pre-existing curriculum from OpenSciEd materials to teach towards racial and environmental justice during their middle school teaching practicum. Teacher education programs maintain and replicate a sense of disconnect from teaching science that is relevant to the sociopolitical contexts of the schools and communities that they prepare students to teach in. In turn, this does not provide opportunities to support PSTs in learning how to practice teaching for social justice. In this qualitative study, we explore how PSTs develop their critical consciousness, as they consider making curricular modifications to teach towards racial and environmental justice.

Strand 7: Pre-service Science Teacher Education

Preservice Teachers' Reflective Practices on Developing Action Research Skills

Seema Rivera, Clarkson University, USA
Preethi Titu*, Kennesaw State University, USA

ABSTRACT
As Action research (AR) provides the opportunity for preservice teachers (PSTs) to engage in research to learn more about teaching and improve their own pedagogy, action research is used with PSTs to develop their teaching skills over the course of a full-year residency in one placement in this single embedded case study. Two PSTs were focused on because of their similarities in programming and selecting the same topic to investigate. The findings indicated that preservice teachers found action research to help them develop as teachers by getting to know their students better and focusing on being student-centered, not just thinking about their pedagogy. Also, we found that PSTs need ample time to make the most of action research during an intensive residency and multiple cycles of data collection and readjusting their action research plan.

Strand 7: Pre-service Science Teacher Education

Evaluating divergent thinking and problem discovery among German Chemistry student teachers

Swantje Müller*, Martin-Luther-Universität Halle-Wittenberg, Germany

ABSTRACT
Creativity is an important skill that is highly relevant in many areas. Especially in natural sciences, creative solutions have been of great relevance for society in the past and will be an important skill to be able to meet global challenges such as climate change with the latest technologies. In school context, creativity is often only combined with musical or artistic subjects. Creativity in STEM lessons has not yet made a big impact, although teachers train the future generation of creative employees. Creative teachers have a better impact on encouraging students' creativity and therefore teacher's creativity is of high relevance. The creative potential of student teachers, pre-service teachers and teachers in STEM subjects has been poorly investigated. In a study presented here, student teachers developed and tested creative teaching material. The creative potential and its development of student teachers has

been tested using a validated test. First results regarding gender and academic parental background among divergent thinking and problem discovery will be presented here.

Strand 8: In-service Science Teacher Education

Inquiry-Based Science Teaching Efficacy of Middle School Science Teachers in a Professional Learning Community

Aeran Choi*, Ewha Womans University, Korea, Republic of
Elsun Seung, Indiana State University, USA
Soonhye Park, North Carolina State University, USA
Soojeong In, Ewha Womans University, Korea, Republic of

ABSTRACT
This study investigated inquiry-based science teaching efficacy of science teachers who have worked with colleagues in a Professional Learning Community over a year for planning, implementing, and reflecting science instruction using eight science practices. Participants of this study were four female science teachers from four different middle schools and voluntarily participated in professional learning community. Interview with each participant teacher was recorded and transcribed as a main data of this study. Supplemental data were transcribed recordings of meetings of professional learning community, teacher written reflection, and field notes of science class. Results indicated that majority of the participant teachers had efficacy of planning and designing inquiry-based science lesson using 8 science practices while they did have efficacy of implementing inquiry-based science instruction using 8 science practices. While participant teachers in this study were engaged in both designing and implementing inquiry-based science instruction, participant teachers in professional learning community spent more time for planning and designing inquiry-based science lesson at the beginning of the meetings of the professional learning community. Results indicated that efficacy of implementing science instruction would take more teaching experiences and follow-up individual and collaborative reflection in a professional learning community to have efficacy of implementing science instruction.

Strand 8: In-service Science Teacher Education

Relationships of PCK to Teacher Quality, Teaching Practice, and Student Outcomes: A Systematic Literature Review

Soonhye Park*, North Carolina State University, USA
Kennedy Kam Ho Chan, The University of Hong Kong, Hong Kong

ABSTRACT
This systematic literature review analyzed and synthesized major findings of the studies on the relationships of science teachers' pedagogical content knowledge (PCK) to teacher quality, teaching practices, and student learning outcomes. Eighty-four empirical studies published from 1986, when PCK was first introduced, to 2021 were selected for this review by a set of inclusion criteria. A coding scheme for the analysis of selected literature was developed based on the conceptual framework derived from existing frameworks for teacher quality and teacher competence. Analysis of the studies revealed that: (1) research on PCK relationships centers more on teacher qualifications and competencies than teaching process or student outcomes;

(2) teaching experience is the most frequently examined teacher qualification variable that appears to be generally related, but not proportional, to PCK development; (3) close links between CK and PCK are empirically supported; (4) findings about the relationship between PCK and teacher affective-motivational characteristics are inconsistent; (5) empirical evidence for the influence of PCK on teaching practices is relatively strong; (6) research on student outcomes in relation to PCK mostly focuses on cognitive domains and shows positive associations between them; and (7) little research on student affective-motivational outcomes exists with mixed findings.

Strand 8: In-service Science Teacher Education

Mapping the Terrain: Using Actor Network Mapping to Help Science Teacher Leaders Understand Their Systems

Sarah Stallings*, University of North Carolina at Greensboro, USA
Sara Heredia, University of North Carolina at Greensboro, USA
Michelle Phillips, Exploratorium, USA

ABSTRACT

This poster presentation will include information about a design based research study where Science Teacher Leaders (STLs) navigated the ways in which they interpret and understand the complex educational systems in which they work. Focusing on a particular activity modeled after Riedy and colleagues (2018), STLs created actor network maps. These actor network maps allowed for the STLs to define their sphere of influence. Researchers specifically were interested in the following: (1) Who and what did STLs include in their actor network map? (2) What tensions and challenges did they surface when generating their map? (3) How did the activity support them to identify supports and barriers to their leadership work? This poster reflects the holes and gaps within science education as well as areas where STLs identified supports needed to attend to science education reform efforts.

Strand 8: In-service Science Teacher Education

Are We Moving toward Equity in Science Talk?: Evaluating Timing and Positioning of Talk Moves

Sierra Morandi*, Florida State University, USA
Sherry Southerland*, Florida State University, USA

ABSTRACT

Within the science education reform movement, there have been long standing calls initiated to attend to equity in the science classroom. These calls are sought to de-settle and advance the broad strokes of "equity for all" into deeper, more meaningful actions, considering the way we view equity and how equitable practices unfold in the classroom. Productive science discourse or productive science talk is just one instructional practice used and discussed which leverages students as sensemakers. This study seeks to better understand productive science talk as a practice of equitation instruction. In examining Ms. Savannah's practice, a high school biology teacher, two major findings emerged around the use of productive talk: (1) pattern of moves to leverage student ideas and (2) timing of moves to stimulate interest or motivation. These talk moves and timing gave insight into talk as both having the ability to hinder and foster student ideas and provide an initial "on-ramp" for students' voices to be heard, taken up,

and have accountability in the classroom. This work continues to sustain a call toward attention to equity and a need to evaluate the equity-aligned practices that are fore-fronted in PDs and workshops.

Strand 8: In-service Science Teacher Education

Changes in Rural Science and Mathematics Teachers' Conceptions of Teacher Leadership and Professional Identity

Christine Lotter*, University of South Carolina, USA
Jan Yow, University of South Carolina, USA
Steve Barth, University of South Carolina, USA
Denae Kizys, University of South Carolina, USA

ABSTRACT

This study investigated changes in rural secondary science and mathematics teacher's conceptions of teacher leadership and their teacher leadership identities while participating in a six-year professional development program. Nineteen rural teachers were interviewed four times over the program to understand how their conceptions of teacher leadership changed as they participated in the teacher leadership program. Qualitative coding was used to determine changes in teacher conceptions over the study period. Our initial research findings revealed that our rural science and mathematics teachers focused their leadership skills on improving student learning and school effectiveness through peer mentoring, community involvement, and increased resource allocation (both student opportunities and teacher instructional resources). Year six interviews specifically addressed the teacher-leaders impact on teacher satisfaction and retention through their social and emotional support of peers as well as science and mathematics instructional support during COVID-19 disruptions. The building of a community of teachers that share ideas, curriculum, and resources with their local communities may ultimately help retain teachers in high-need rural districts, reducing isolation and improving student learning of mathematics and science.

Strand 8: In-service Science Teacher Education

High School Teachers' Use of Technology: Portraiture in Educational Action Research

Gerald Tembrevilla*, Mount Saint Vincent University, Canada
Kimberley Gomez, University of California - Los Angeles, USA
Marina Milner-Bolotin, University of British Columbia, Canada

ABSTRACT

Recent initiatives in the Philippines, the site of this study, have stressed the importance of teachers engaging in education research. In this study, we employed action research to reframe the relatively uncontrolled circumstances brought about by the wider implementation of information and communication technology (ICT) policies and initiatives in the context of science education. We draw from the first author's overlapping identity as an insider-outsider-in-between in relation to the five science teacher-participants and their pre-to-post video production engagements and reflections during science video workshops throughout a 45-day fieldwork. We also draw on portraiture methodology to examine select science teachers' challenges as they integrate ICT in their classes. With further analysis of participants'

interviews during the pre-to-post video production stages framed through the lenses of technological, pedagogical, content knowledge (TPACK) and funds of knowledge (FoK), this study offers three portraits of science teachers' challenges.

Strand 10: Curriculum and Assessment

Preservice Teachers' Answer Changing Behaviors on a Content Knowledge for Teaching Science Assessment across Timepoints

Jamie Mikeska*, ETS, USA
Katherine Castellano, ETS, USA
Steven Holtzman, ETS, USA

ABSTRACT
Research emphasizes that science teachers need to leverage their content knowledge for teaching (CKT), which includes both their subject matter knowledge and pedagogical content knowledge, as they engage in critical science teaching practices. However, there are few instruments designed to measure the full breadth of science teachers' CKT efficiently at scale. In our larger research project, we addressed this gap by developing a discretely scored online assessment to measure elementary preservice teachers' (PSTs') CKT about matter and its interactions. But to build a comprehensive understanding of how elementary PSTs engage with the CKT matter items on this assessment, research needs to examine not only their final answer selections but also the response processes they used to arrive at those final answers. To that end, in this study we examine and compare PSTs' answer changing behaviors on the CKT matter assessment at two timepoints – at the beginning and end of one semester – and do so across multiple class sections. This research provides a way to develop a more comprehensive understanding of how PSTs' interact with the CKT matter items on this assessment and to discern if there are any patterns in their answer changing behaviors across timepoints.

Strand 11: Cultural, Social, and Gender Issues

A Framework for Making Sense of Acts of Resistance and Coalition-Building in Secondary Science Classrooms

Linsey Brennan*, Michigan State University, USA
Christina Schwarz, Michigan State University, USA

ABSTRACT
As students take up scientific practices and engage in social and communal interactions within the classroom, they are required to navigate the power dynamics and biases of society writ large. Within this reality, acts of resistance by students (and subsequent coalition-building) are inevitable. In contrast to more traditional views of student behavior, we developed a new framework to support teachers and students in seeing and interpreting student acts of resistance and coalition building as important and necessary communication of injustices. The framework is used to make sense of "The Case of Carla" (Kurth et al., 2002) and in the process, it highlights the impact of racialized societal narratives and student positioning on Carla's acts of resistance. Future directions of this work will focus on how the framework can

be used to support teachers and students in reframing their interpretation of acts of resistance and how they respond as a result.

Strand 11: Cultural, Social, and Gender Issues
Virtual Reality for Distance Culturally Revitalizing Pedagogy
Jared Tenbrink*, University of Michigan, USA

ABSTRACT
American Indian youth are underrepresented in post secondary educational spaces, especially the sciences. Educational scholars have written about uniqueness of American Indians and the importance of culture and cultural education for supporting American Indian youth. Educational initiatives that center land-based curriculum, Indigenous Ways of Knowing, tribal culture, language, and educational pedagogies have been effective in uplifting American Indian youth. However, these programs have all been in person and most American Indians live off reservation in urban areas. There is a gap in the research, how can curriculum and pedagogy support tribal youth who are unable to participate in in-person initiatives? Distance and mobile based education initiatives have been shown to be effective for Indigenous peoples around the world, but there is limited understanding in North America. Virtual Reality may provide a bridge to connect Culturally Revitalizing Pedagogies and distance learning by allowing for immersive, land based learning experiences for individuals who are unable to attend and participate in person.

Strand 11: Cultural, Social, and Gender Issues
Defining Justice-Oriented Science Teaching: A Domain Model
Megan Walser*, Michigan State University, USA

ABSTRACT
Reform efforts continue to call for "science for all," but this call is insufficient for making science accessible and meaningful for marginalized students. Therefore, it is imperative to investigate approaches to science education that are more justice-oriented. This paper presents a domain model of constructs associated with justice-oriented science teaching, drawing from the frameworks of asset-based pedagogies and epistemic agency. The model includes five domains: supporting academic achievement, affirming students' cultures, developing students' critical consciousness, positioning students with epistemic agency, and valuing students' ideas. The model defines these domains based on relevant literature, and presents possible evidence that could indicate that teachers are thinking about the domains and putting them into practice. This domain model can be used to develop instruments to collect data on teachers' thinking and enactment of justice-oriented science teaching, and presents a vision for future research in this area.

Strand 11: Cultural, Social, and Gender Issues
Language of science versus language for science: Centering multilingual students' languaging practices in science education
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
Samuel Lee, Boston College, USA

ABSTRACT
In this theoretical position paper, we problematize how language has been conceptualized in the field of science education, discuss and offer examples of how dominant views of language have been consequential on both research and practice, and propose a shift away from the idea that there is a language of science, and towards views of how learners use language for science. This shift is grounded in our commitment to create more equitable and just learning environments for students from minoritized language backgrounds - specifically, multilingual students - transforming science education to center learners' heterogenous and wide-ranging languaging practices. In particular, we present translanguaging as an expansive approach that is aligned with the language for science model that has the potential to shift science teaching and learning with multilingual students.

Strand 11: Cultural, Social, and Gender Issues
The impact of various spaces on science majors' science identities
Allyson Randall*, Boise State University, USA
Sara Hagenah, Boise State University, USA
Karen Viskupic, Boise State University, USA

ABSTRACT
Despite growing need for qualified individuals in the STEM workforce, we continue to see a lack of diversity in STEM fields, limiting the perspectives of individuals entering the workforce. To better understand the experience of undergraduate science majors, we conducted a qualitative study, interviewing undergraduates from geoscience, biology, chemistry, and physics majors to understand their experiences with science identity. We chose to use spaces as our unit of analysis, with a focus on the objects and people within those spaces. We found the field to be a significant space for geoscience majors and some biology majors, both in positive ways and negative. A love for doing science outdoors led many students to their major, but others had challenges feeling like they belonged due to challenges in the field. We found objects to have significance for students in field spaces more so than classroom or laboratory spaces and the importance of representation in scientific spaces. It was important for students to share space with individuals who look like them or dress like them. These findings have significant implications for equity in science, taking into consideration the need for positive role models and the variability in experiences students had in the field.

Strand 11: Cultural, Social, and Gender Issues
Literature Review: Tools for Assessment of Inclusive Practices
Natalia Franca*, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, University of Missouri-Columbia, USA
Hai Nguyen, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, University of Missouri-Columbia, USA
Ritesh Sharma, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, University of Missouri-Columbia, USA

Saaedah Albishi, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, University of Missouri-Columbia, USA
Courtney Ngai, Empowered Consulting, United Kingdom
Marcelle Siegel, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, and Department of Biochemistry, University of Missouri-Columbia, USA

ABSTRACT
Inclusive practices have been recommended as an approach to support the increasing diversity of students in the classroom. However, to date, not much research has sought to map the tools available to investigate inclusive practices, as well as to establish how educational researchers conceptualize and measure these. In this literature review, the ERIC and Scopus databases were used to understand what is being discussed and published about the topic: tools for Assessment of Inclusive Practices. After a research-based process of article selection, we discuss the tools available that use different methods and theoretical frameworks to measure and document inclusive practices within multiple educational contexts. Five major kinds of challenges associated with development and implementation of these instruments were found. Results reported in this study have the potential to generate discussions around the pedagogical possibilities and hindrances related to the use and development of tools for effective inclusive pedagogical practices.

Strand 12: Technology for Teaching, Learning, and Research

Research-based practice regarding delivery of K-12 science instruction online: A systematic literature review

Carla Johnson*, NC State University, USA
Janet Walton, NC State University, USA

ABSTRACT
This systematic literature review study was funded by the Institute of Education Sciences in the summer of 2020 in response to the need to investigate the empirical research base regarding online delivery of full-time instruction for K-12 students, with particular focus on science instruction. The goal of the study was to generate insights that could be leveraged to inform the work of teachers, teacher educators, researchers, administrators, and policy makers during the current emergency-based online delivery of K-12 curriculum necessitated by the COVID-19 pandemic, and to provide evidence-based guidance for the resulting longer-term shifts in educational practice that are likely to result from the pandemic.

Findings demonstrated there are three distinct considerations that should be understood by teachers and other instructional designers when planning and implementing an approach to full-time online science teaching in K-12 education. Further, there are seven essential instructional components: 1) evidence-based course design; 2) connected learners; 3) accessibility; 4) supportive learning environment; 5) individualization and differentiation; 6) active learning; and 7) real-time assessment. Implications for science education and suggestions for future research will be discussed.

Strand 12: Technology for Teaching, Learning, and Research

Machine Learning to Predict Science Student Outcomes Using Neurological Data

Richard Lamb*, East Carolina University, USA
Knut Neumann, IPN, Germany

ABSTRACT

Automated interactive learning management systems and the associated online video-based learning environments are thought to increase student learning outcomes related to science content and practices. However, adaption of content during the process of learning is difficult because of the complexity of assessing student cognitive state in real-time. However, the use of neurological measurement may provide a partial answer to this problem. The purpose of this study is to examine how hemodynamic response data may be used to develop student level answer predictions via machine learning algorithms as students engage with an online learning management system in a science classroom. Within this study fNIRS data (e.g., hemodynamics data) from the PFC was used to create prediction of student answers on a science content test. Results suggest that hemodynamic responses observed during content presentations to the students is predictive of student success on the content test. The interactivity in a virtual teaching environment can increase student engagement and, therefore may reinforce learned concepts and provide a means to deliver on-demand learning without a human in the loop.

Strand 12: Technology for Teaching, Learning, and Research

Using technology to promote student metacognition in large enrollment STEM courses

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 in which students add annotations and discuss the content with each and with the instructor. The objectives of this project are to learn about the delivery of the asynchronous intervention by examining the nature and extent of student annotations, and to learn from the student contributions concerning their views of evidence-based learning strategies, their prior knowledge of the subject, how they intend to change or retain learning strategies, and their overall view of metacognition. Student engagement with the asynchronous video was high and provided insights into student perspectives on many topics. Among these, it was found that students begin the class with a growth mindset in which success is attributed to one's behavior and motivation rather than their learning strategies. Student perspectives on specific learning strategies is diverse, with treating homework as an opportunity for self-assessment being perceived as most novel and worth adopting in the future.

Strand 12: Technology for Teaching, Learning, and Research

The T in STEM Education: "ICT", "T" or "t"?

Heba EL-Deghaidy*, American University in Cairo, Egypt

Poster Session A, 4/20/23, 14:50-15:35

Mohamed El Nagdi, American University in Cairo, Egypt

ABSTRACT
STEM acronym has been a buzzword with various interpretations to what it really means by each of its letters with additional debate around the 'T' in STEM. Here we explore what 'T' in STEM means in the context of STEM schools in a Northern African country as a synergetic discipline along the other STEM disciplines. A case study research design is used to answer the following research questions: How do school teachers and leaders in STEM schools perceive technology integration? What distinctive technology tools are found and used in STEM schools that characterises such schools? Teachers and school leaders in two STEM schools responded to questions through focus group discussion. The study highlights the pivotal role of technology in STEM including the role of Fabrication Labs as a distinctive feature in STEM schools.

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

Effectively Teaching Nature of Science in a Way that Coexists with Religious Principles

Tina Stamper*, Indiana University, USA
Nicole Conrad Nelson, Indiana University, USA

ABSTRACT
This study aimed to determine (1) how values and faith affect students' views on the nature of science (NOS), and (2) how teachers can more effectively and accurately teach students that science and religion are compatible with one another. Senior students from a private, Christian, high school were recruited to participate in four NOS-related activities while receiving explicit NOS instruction. In addition, students completed an open-ended questionnaire, pre- and post-NOS instruction, that addressed their thoughts on scientific and religious compatibility. A teaching log, critical friends' meetings, and students' verbal commentary were also used in the data collection process. Results showed, in both pre- and post-NOS instruction, that the students' values and faith substantially effected their views on NOS, which may in turn prevent them from learning about or discussing certain science-related topics. Results also indicated that past instruction may not have provided accurate or complete information in regard to certain scientific topics, and that how a teacher teaches something is just as important as what is being taught. Based upon our findings, teachers should equip themselves with accurate and complete information in an attempt to increase scientific literacy and decrease misconceptions that students may hold regarding religious and scientific compatibility.

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

The role of designed educational purposes in raising the accessibility of authentic scientific purposes

Haya Ben Simon*, Technion, Israel
Michal Dvir, Technion, Israel
Dina Tsybulsky, Technion, Israel

ABSTRACT
The introduction of novices to the disciplinary culture of science through engaging in authentic disciplinary practices, necessitates introduction to the authentic scientific purposes that guide their enactment. However, these may be inaccessible for young students, or incompatible with their personal, actual purposes. The designed activities to foster their introduction, and the designed purposes for each activity, should therefore bridge the potential differences between the authentic and the students' actual purposes. Focusing on a context that is particularly-suited for engaging students with authentic scientific endeavors, Citizen Science projects, this study explored the roles that designed purposes can play in mediating the authentic scientific purposes. A case study of a pair of middle school students illustrates the affordances of adapting the projects' authentic purposes to build on students' knowledge, views, and motivations. As the pair engaged in the designed learning sequence, they gradually appropriated all of the designed purposes of its activities, leading them to also appropriate the authentic purposes that inspired them. However, particularly consequential was a designed purpose solely inspired by pedagogical considerations and not the authentic purposes of the project. The conclusions of the study advocate for the inclusion of such considerations in designing authentic educational settings.

Strand 14: Environmental Education and Sustainability

Psychosocial determinants of pro-environmental behaviors studied in the last decade: A systematic review of research.

Aparajita Rajwade*, North Carolina State University, USA
K.C. Busch, North Carolina State University, USA

ABSTRACT
Increased environmental degradation has led to a growing focus on using environmental psychology to understand proenvironmental behaviors. There is also special focus on studying the influence of different psychosocial determinants on proenvironmental behaviors amongst both children and adults. A systematic literature review was conducted to analyze peer-reviewed literature to identify the nature of psychosocial determinants research within the last decade. In the resulting sample of 26 articles, we identified 21 different psychosocial determinants, finding that attitudes, norms, beliefs and worldviews, and values are the most commonly studied across a range of disciplines and countries. Discussions from this review highlight the various conceptualizations and instruments used by researchers to describe psychosocial determinants, while also highlighting lack of conceptual clarity. This suggests a need for focusing more on understudied psychosocial determinants and a need for comprehensive definitions while advancing proenvironmental behavior theories.

Strand 14: Environmental Education and Sustainability

Connecting an Environmental Education Center & Science Standards: A Document Analysis

Hamza Malik*, University of Massachusetts Dartmouth, USA
Rachel Stronach*, University of Massachusetts Dartmouth, USA
Stephen Witzig*, University of Massachusetts Dartmouth, USA

ABSTRACT
Environmental Education is a challenging field within the realm of science education. The objective of EE highlights that we in our society need competent citizens who are equipped to tackle environmental issues utilizing a transformative lens. Environmental education centers are at the forefront of teaching students about environmental issues. This research focuses on ways in which Dale Center for the Environment (DCE) attends to the Massachusetts Science Standards when teaching science utilizing in-school and out-of-school settings. We conducted a document analysis utilizing multiple sources i.e., historical DCE datasheets from 2017-2021, the Massachusetts Curriculum Framework document, the center's website, program sheets, and teacher/student packets. Findings were organized around emergent themes connecting to our CF construct(s). Results support three key assertions which are connected to each of the DCE's programs 1) DCE's in-school programs connect to the science standards & focus on key student discussion(s), 2) DCE's out-of-school programs connect to science standards while providing students with hands-on experience in an outdoor setting connecting with their local environment, and 3) DCE's hybrid programs introduce students to concepts of Earth & human activities in a way that makes them think about how humans are connected to nature.

Strand 14: Environmental Education and Sustainability

Narratives of change: Fostering Transformation Toward Sustainability Through Science Education

Giulia Tasquier*, University of Bologna, Italy
Alfredo Jornet, University of Oslo, Norway
Erik Knain, University of Oslo, Norway

ABSTRACT
We live in times of unprecedented change and, beyond the urgency of the recent COVID19 pandemic, climate change and sustainability are among the major issues that humanity is addressing and that require epoch-making decisions. Despite a growing attention, science at school still seems to fail in being supportive for students' making sense of these demanding socio-scientific questions. The fact that almost half of national curricula all over the world don't refer explicitly to climate change is a representative example of the delay that formal education has with respect to societal challenges. As science educators, how can we support school students in transforming the base of knowledge and experiences to face the ongoing crises and to enable the required transformation? In the context of such complex problems, narratives become a crucial means for integrating scientific knowledge and critical thinking skills needed to trigger transformative actions. We address this broader issue through a study framed within the XXXproject, aimed at promoting narratives and scenario building as scientific tools to empower students to become agents of change. In this paper, we illustrate our approach and the design of the activities and the use of a SenseMaker questionnaire together with some very preliminary findings.

Strand 14: Environmental Education and Sustainability

Cultivating Climate Change Awareness: Increasing Knowledge and Changing Attitudes

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

ABSTRACT
The purpose of this research was to examine the influence of a year-long nonformal environmental education program on teachers' and students' knowledge and attitudes regarding climate change. Data were collected from teachers and students in a high-minority, economically disadvantaged school district in southeast Texas, who participated in the program throughout the school year. Findings indicated teacher and student participation increased their knowledge of climate change. Teachers also reported increased confidence levels in teaching climate change and a greater level of understanding of climate change, environmental literacy, and stewardship. Students' stewardship practices positively increased due to the realization of the importance of taking care of the environment and that their actions have an impact on the environment.

Strand 15: Policy, Reform, and Program Evaluation

Developing a District Science Assessment: A Case Study of a Local Reform Effort

Elizabeth de los Santos*, University of Nevada, Reno, USA
Lyndsay Munro*, University of Nevada, Reno, USA
Sylvia Scoggin*, Washoe County School District, USA
Rebecca Curtright*, Washoe County School District, USA
Dustin Coli*, Washoe County School District, USA

ABSTRACT
This paper presents a case study of a local effort to develop district level science assessments in response to science education reforms in the United States. The study investigates the process of how a cross-functional team of science educators, content experts, district personnel, and classroom teachers successfully developed a science assessment. Qualitative data analysis using the concept of legitimate peripheral participation identified four themes related to prior relationships, overlapping expertise, connections with professional organizations, and dialogue to make sense across boundaries. This study contributes to an understanding of how complex organizations like school districts can support reform efforts on a large scale.

Poster Session B
4/20/23, 1535-16:20, Grand Ballroom (L2)

Strand 1: Science Learning: Development of student understanding

A Multiple Case Study of K-2 Students' Understanding of Sequencing

Kristina Tank*, Iowa State University, USA
Tamara Moore, Purdue University, USA
Anne Ottenbreit-Leftwich, Indiana University, USA

ABSTRACT

Recent years have shown growing enthusiasm and awareness of the need for computational thinking (CT) education opportunities. Scholars have suggested integrating CT/CS into existing curriculum, especially in areas such as math or science. Further support has come with the acknowledgement of CT as one of the eight scientific and engineering practices within the Next Generation Science Standards. Unfortunately, there is a limited understanding on how to engage early elementary school students in computational thinking, especially within the context of subject areas. In order to better understand how elementary students' learn CT, this study is looking at early elementary students' understanding about sequencing, which is one of the components of the CT concept of algorithm development. The research question that is guiding this work is, what are the attributes of K-2 students' learning and understanding of the sequencing component of algorithm development? As part of that work, this study uses a multiple case study design to examine K-2 students' learning of sequencing through a series of task-based interviews. For this presentation, the case descriptions from each of the cases will be presented in more detail along with findings related to the cross-case comparison.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Do students engage in motivated reasoning when evaluating evidence related to socioscientific issues?

Rachel Sparks*, University of Nebraska-Lincoln, USA
Jenny Dauer, University of Nebraska-Lincoln, USA

ABSTRACT

Limited research has focused on student evidence evaluation in the context of socioscientific issues (SSI), contentious ill-structured issues that require reasoning about science and societal elements. Because of the nexus between lived experiences and SSI, evidence evaluation in these contexts is subject to motivated reasoning, in which individuals' reasoning may have accuracy orientations to reach an accurate conclusion or directional orientations to reach a desired conclusion. We investigated the relationship between motivated reasoning and students' evidence evaluation while reasoning about (1) a personally relevant SSI, agricultural water conservation, and (2) a distant SSI, global plastic pollution. Evidence evaluation was measured through an exercise requiring students to explicitly connect evidence to alternative solutions to the SSI, with students' responses considered more accurate if they matched experts' interpretation. Motivated reasoning was measured using a survey instrument

administered within the evidence evaluation task. Linear regressions showed that students' accuracy of evidence evaluation was predicted by motivated reasoning in the water conservation SSI, but not the plastic pollution SSI. This study suggests that students may exhibit directional orientations around certain SSI, thwarting outcomes such as accurate evidence evaluation, and underscores the importance of instructors considering students' identities when selecting SSI to engage students.

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

Parents' Expectancy Value Factors: Measuring Future Science Task Value and Science Achievement Value

M. Gail Jones*, NC State University, USA
Katherine Chesnutt, App State University, USA
Megan Ennes, University of Florida, USA
Daniel Macher, University of Graz, Austria
Manuela Paechter, University of Graz, Austria

ABSTRACT

This study applied an expectancy value framework to measure science capital, family habitus, science achievement value, and future science task value for parents of elementary-aged youth. Parents' attitudes and beliefs toward science were examined with confirmatory factor analysis. Expectancy value variables were measured and examined in relation to future science task value. The results showed the best fit was a 7-factor model to measure parent attitudes toward STEM and the value of science as a career for themselves and for their child. The findings showed the assessment had high reliability. The parental assessment allows for the measurement of variables that have been shown to predict career aspirations for elementary and middle school youth. The results show we can measure expectancy value factors (e.g., science task value, achievement value) for parents reliably providing the opportunity for these factors to be examined in relation to those of their children.

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

Learning about the Water Cycle: Establishing an Out-of-School Laboratory in Primary Education

Annika Krüger*, University Duisburg-Essen, Germany
Marc Rodemer, University Duisburg-Essen, Germany
Stefan Rumann, University Duisburg-Essen, Germany

ABSTRACT

Out-of-school laboratories, which are developed especially for primary school students, have only existed in a few places so far. Since out-of-school laboratories can have positive effects on students' learning, in this project a project day on the topic of "water" and "water cycle" for a third-grade class was developed. The aim of the project day is to introduce students to the method of experimentation and to measure their knowledge gains in the areas of "states of water" and "water cycle".

To measure students' learning gains, a subject knowledge test on the topic of "water and the water cycle" was developed and piloted with several classes (N = 100). Since the water cycle requires the use of models, model comprehension will also be investigated. The students

transfer the findings from the experiments into a "classical" and an "erroneous" model of the water cycle, since learning from errors is a promising form of learning that has hardly been systematically investigated so far. Rasch-modelling of the test pilot promises high test reliability. Results from the pilot as well as the main study will be presented.

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

Investigating how Ambitious Science Teaching and Responsive Moves Support a Science-as-Practice Teaching Approach

Sahar Vali*, West Virginia University, USA
Melissa Luna, West Virginia University, USA

ABSTRACT
A common thread in science education research focuses on children's engagement in science and engineering practices as they pursue conceptual understanding of scientific phenomena. Many of the current reform efforts have thus focused on both learning science and teaching science through a science-as-practice approach. This work builds on the teaching science-as-practice research to examine how a teacher responds to her students as they are engaged in disciplinary practices while she herself is engaged in Ambitious Science Teaching (AST) implementation practices. Three key findings include: (1) the teacher most often made moves that supported pressing for evidence-based explanations; (2) asking questions was the most prominent teacher move, but the kinds of questions varied depending on the AST practice the teacher was engaged in, and (3) no matter the AST practice, the teacher made moves that made students' ideas public and items of inquiry for both herself and her students. This work contributes to the field's understanding of how a science-as-practice teaching approach is supported both through ambitious science teaching practices and the associated teacher moves that are at play.

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

Seeing the Forest Through the Trees: Enhancing Phenomenon-based Science Teaching Through Contextualization

Kraig Wray*, Pennsylvania State University, USA
Jonathan McCausland*, New Mexico Highlands University, USA
Emma Jacobson, Pennsylvania State University, USA
Scott McDonald, Pennsylvania State University, USA
Amy Pallant, The Concord Consortium, USA

ABSTRACT
Choosing a relevant and appropriate anchoring phenomenon is one of the most challenging yet essential tasks to supporting student engagement in the practices of science characterized in the NGSS (NGSS Lead States, 2013). Ideally, the phenomenon should provide opportunities for students to leverage their experience, be relevant to them both culturally and within their community and allow for them to make sense of the science through their own ways of knowing. However, in this study, we saw that most students maintain a separation between their lived experiences within their communities and the ways they make sense when

participating in school. Despite direct experience with wildfire, while completing an online module focusing on the risks and impacts of wildfire, even when directly asked, students rarely drew on those experiences to help explain or justify their thinking regarding wildfire. We found, by contextualizing, or explicitly drawing on either the students or the teachers lived experience, references to these experiences tracked through a unit and the students drew on the contextualized experience to make sense of the anchoring phenomenon.

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

Success Conditions of effective Problem Solving in Physics and Chemistry Education: A Systematic Review

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ABSTRACT

As one of the 21st Century Skills, problem solving has proven to be an elementary skill in STEM-education. In particular, it is central in physics and chemistry education due to the important function of experiment and phenomena. Due to actual student difficulties with problem solving at the high school and college levels, ambiguities about and growing differentiation in instructional methods (problem- and inquiry-based learning), and problems such as the bandwidth-accuracy spectrum of concrete methods, a comprehensive review of the literature in physics and chemistry education is performed. Using an analysis of existing reviews as well as performing a qualitative and quantitative systematic review, problems are revealed and methods that work are derived. By analyzing the more than 22,000 articles found, a growing activity of problem solving research in physics and chemistry education is recognized, which is particularly striking for chemistry. Domain-specific literature with a strong problem orientation can be identified, as well as those with generalizable applications. In addition, an extensive literature on technology-specific teaching methods is recognized. Overall, extensions of theory as well as implications for physics and chemistry instruction can be derived that can be incorporated into a STEM-friendly educational environment.

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

The Impact of an International Research Experience on Undergraduate and Graduate Students' Understandings about Science

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ABSTRACT

This study describes the impact of an international research experience for undergraduate and graduate molecular biology students on their understanding of scientific concepts and research techniques as well as on their perceptions about science in a global context. Six

students from across the United States spent nine weeks in Japan, mentored by established researchers at three institutes. The students engaged in research on molecular adaptations to seasonal and circadian behaviors in medaka fish. Qualitative data from sources including interviews, surveys, weekly logs, and meeting transcriptions were analyzed with respect to what the students learned and how their worldviews were affected by the experiences. Our analysis revealed that students gained content knowledge as well as exposure to new research techniques from the targeted mentorship. Through their immersion in a different cultural environment, they gained insights into cultural differences that manifested themselves in the laboratory, potentially influencing how they approach science in the future. Furthermore, students noted the influence of the program on their plans as budding researchers. This poster will report on findings from Year 1 of a three year program.

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

Development and Validation of an Instrument Measuring Motivation Among Undergraduate Anatomy and Physiology Students

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ABSTRACT

Undergraduate students in anatomy and physiology have varying levels of motivation for being successful. This is especially true if they are planning to enter healthcare programs. According to self-determination theory by Ryan and Deci, three psychological needs of autonomy, relatedness, and competence must be met in order for optimal motivation and learning to occur. The following study details the development and validation of an instrument measuring autonomy and relatedness among anatomy and physiology students. Items were adapted or developed from other studies based in self-determination theory and the scale was validated using exploratory factor analysis. Item elimination involved an iterative process through which multiple components were considered including theory, factor loadings, communalities, alpha, and factor strength. The final model utilized oblique factor rotation concluding with a 24-item instrument across three factors: autonomy, sense of belonging – instructor connection, and sense of belonging – peer relations. Factor loadings were strong ranging from 0.49 to 0.97 with no salient crossloadings. Potential implications for the instrument include future studies to examine anatomy and physiology instruction, analyze construct magnitude and correlation, conduct causal comparative studies among students from different backgrounds, and eliminate barriers for underrepresented students intending to enter healthcare fields.

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

Meta-Agency in Problem-Based Learning: How Do Students Exercise Their Agency?

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ABSTRACT
In college cybersecurity education, problem-based learning has been introduced to promote student agency in solving a complex problem. However, a dilemma of balancing the student agency persist as prior research has shown higher degree of student agency does not always promote student learning. While previous research has focused on students' cognitive, metacognitive, and regulatory to enhance the efficacy of PBL, how (well) students recognize and exercise agency has yet to remain uncovered. Assuming students' positive awareness and effective exercise of meta-agency would impact the effectiveness of students' agency in PBL, this study suggests a concept of meta-agency as an essential learner characteristic that mitigates the detrimental effects of students' higher agency. Four dimensions of meta-agency (i.e., perceptions of productive struggle, expectation alignment between instructor and students, strategies for regulating agency, and familiarity with PBL tasks) were qualitatively explored with student interview data. Features of each dimension of meta-agency were further suggested with exemplifying remarks from student interviews.

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

The Effect of Gestures in Teaching and Learning Anatomy and Physiology

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ABSTRACT
Some undergraduate science courses have the reputation of being "gatekeeping" or "weed out" courses because students must achieve a grade of C or better to continue with coursework in the student's chosen STEM major (Keen-Rinehart et al., 2014). One such course is anatomy and physiology for nursing and kinesiology students (Lunsford & Diviney, 2020). The volume of material and complexity of the content are two reasons why the course is difficult for students to master, and nationally has a high drop/fail/withdraw rate. Gestures are commonly used by teachers and students when teaching and learning. Roth (2001) ties gestures to cognition, and Alibali and Nathan (2012) link gestures to concept development, but little has been done to study effects of gestures in science education, especially at the postsecondary level. This study examines the role of gestures in teaching and learning in an undergraduate anatomy and physiology course and asks these research questions: 1) Do pointing gestures by students affect student outcomes more than pointing gestures by the teacher alone? and 2) Do representational gestures by students affect student outcomes? We found that representational gestures helped students learn cranial nerve content compared to students who did not use gestures.

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

Developing a Clicker Question Sequence (CQS) to Improve Students' Understanding in Quantum Mechanics

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ABSTRACT
Active and interactive learning have long been used in introductory STEM classrooms at the college level, but their impact has been less investigated in upper-level courses for majors. Using the interactive component of clicker questions, we developed and validated a Clicker Question Sequence (CQS) for use in an advanced undergraduate quantum mechanics course. This research investigates the effectiveness of a CQS in helping students learn concepts related to the time evolution of two-state quantum systems. To do this, we evaluated students' performance after traditional lecture-based instruction and compared it to their performance after engaging with the CQS. The findings indicate that a CQS is effective in both a virtual and in-person classroom.

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

Authoritative Discourse Used in Math Integrated Science Instruction and Sensemaking Opportunities

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ABSTRACT
Multiple calls in both science and mathematics education argue for a shift in instructional practices away from rote learning and towards sensemaking. Included in this call is a more student-centered approach to teaching such integrated topics. There has been much work into grade level instruction and discourse however, the same investigation needs to extend into undergraduate biology instruction. This study documents current teacher discourse moves (TDMs) which focus on specific verbal instruction teachers employ to support student understanding of content knowledge, within the instruction of undergraduate biology population growth using mathematical equation instruction. Sensemaking opportunities were cross plotted within the same instruction. We found that instructors still use authoritative TDMs while instructing integrated topics. In addition, we found instructors also use the same authoritative TDMs when providing sensemaking opportunities no matter if these opportunities are separate or blended. These findings suggest the need for more professional development providing instructors more usable resources in a student-centered approach.

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

Distance dilemma: The impacts of the COVID-19 pandemic on student impressions of science instruction

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Felicia Leammukda*, St. Cloud State University, USA

ABSTRACT
The purpose of this study is to analyze and collect student impressions on the effectiveness of online versus in-person science instruction for Midwest University (pseudonym) students. The research question that guided this research is the following: How does online science instruction impact the learning experience of Midwest University students? Midwest University students who have taken at least one science class since June 1, 2020 will be surveyed regarding their experiences with online learning during the pandemic. Select students will

participate in a follow-up interview. A qualitative approach will be used in this study, with a planned future mixed-methods approach for continuing work. Researchers will separately code student responses and codes will be consolidated into themes. Preliminary results show that students experienced hybrid, virtual, and in-person learning, and there were both benefits and difficulties with online learning. Benefits with online learning include flexibility in scheduling, synchronous lectures, alternatives to discussion posts, no missing class due to illnesses, and more overall structure. Difficulties with online learning include maintaining focus, lack of interactions and connections, difficulty in retention, and it is more expensive.

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

Impact of Study Strategies on Knowledge and Exam Performance in Medical School

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ABSTRACT
Studying plays an important role in the academic success of medical students. It is likely that ineffective study skills result in poor performances on required standardized exams. There is a concern for the lack of empirical data related to what study strategies are the most productive for medical students to practice.
In July of 2017, the incoming class of first year students (graduating class of 2021) at an allopathic medical school in the Midwestern United States (120 students) were given a survey at the beginning of medical school (August of 2017) to evaluate their study habits.
We examined the relationship between the study strategies students reported to use and their academic performances measured by their success on the following standardized examines: Comprehensive Basic Science Exam 1 (CBSE1), Comprehensive Basic Science Exam 2, (CBSE2) distributed by the National Board of Medical Examiners (NBME), and the Step 1 Exam, distributed by United States Medical Licensure Examiners (USMLE). Data suggest that students use a collective of deep processing strategies with an emphasis on contextualization to achieve greater learning outcomes and increase scores on the USMLE Step 1 exam.

Strand 6: Science Learning in Informal Contexts

Science Museum Educators' Teaching Self-Efficacy For Online Programming

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ABSTRACT
Due to COVID-19, many museums closed their doors in 2020 and began offering online programming. Online programs allowed museums to reach visitors who may not otherwise be able to visit and new ways of engaging with audiences. However, for many museum educators, teaching online was a new experience. Whether educators choose to engage in particular tasks and how much energy they will devote to the activity is related to their levels of teaching self-efficacy. Educators with higher levels of teaching self-efficacy are more likely to engage in a

particular task and believe they will be successful in facilitating the activity. The authors of this surveyed 406 science museum educators to explore their levels of teaching self-efficacy for a wide range of tasks. This manuscript focuses on the eleven questions related to teaching online. The respondents had high levels of self-efficacy for most items related to teaching online. The two items that were rated the lowest were their ability to facilitate online programs with preschool and university students. Understanding educators' levels of teaching self-efficacy can help museums create professional development opportunities tailored to the needs of their staff as well as for researchers to design interventions to address those specific needs.

Strand 6: Science Learning in Informal Contexts

Learning Talk Among Middle School Students at a Science Museum Exhibit

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ABSTRACT

Informal learning environments play an increasingly vital role in promoting science learning for children. However, there are many questions about how children co-construct knowledge in these settings. Using a sociocultural perspective, this study examined patterns of learning talk among small groups of middle school students at an informal science museum exhibit that highlighted the contributions to physics of scientists from underrepresented backgrounds. Results indicated that students engaged in dynamic conversations while engaging with exhibit components and frequently switched between different kinds of learning talk. Patterns of student talk also suggested that specific categories of learning talk often co-occurred in students' discussions of exhibit components. Implications for research and exhibit design were discussed.

Strand 6: Science Learning in Informal Contexts

Space & Place: How Afrofuturism and Sense of Place Can Revolutionize Outdoor Science Education

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ABSTRACT

Outdoor education (OE) can be a space for students to learn science through fun physical and experiential activities. Currently, there are limited studies in OE on the effect of western, dominant epistemologies and how this framing of the outdoors can be harmful, especially to Black students. The three concepts that I've structured this research around are Afrofuturism, Sense of Place, and Black Liberatory K-12 Science Education (BLKSE). When combined, these concepts within a Black outdoors program may initiate refusal and resistance to accept white supremacy, critical consciousness around racism and uplifting marginalized histories, and hope of diversity and equity within outdoor spaces for Black OE educators. Five outdoor programs across the United States that centered Black or BIPOC students were chosen to identify how

OE thinking was reflected in their programs. While science education is not clearly embedded in these Black outdoor programs, how science education has been framed may limit the perception of who can do science and what counts as science learning. Based on the mission statement, values, and program overviews, the focus on BIPOC students, their lived experiences, and their sense of place is essential to more inclusive science educational practices.

Strand 6: Science Learning in Informal Contexts

Measuring Student and Program Success in STEM Undergraduate Research Programs

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ABSTRACT

Numerous Research Experiences for Undergraduates (REU) programs are being funded by the NSF. Research regarding REU programs typically evaluates the effectiveness of the Principal Investigator's (PI) individual programs, whereas our study examines a sample of REU programs as well as other undergraduate research programs. This mixed-methods study explores the effect these undergraduate programs have on REU research fellows and other undergraduate student researchers and how their success was measured. Questions included: How are REU programs measuring success of their REU fellows? How do undergraduate researchers view success in their research program? How do PI's and undergraduate researchers' views of success in their respective research programs compare? We conducted interviews with ten PIs. We sent surveys to REU fellows and to other undergraduate researchers. PIs and their respective fellows listed similar production metrics such as: publications, presentations, and posters. PIs and their fellows heavily focused on graduate school and future plans as opposed to other undergraduate researchers. Most fellows considered research skills as one of their most important gains whereas PIs did not specifically mention research skills as a measurement of success, most likely due to the fact that it is an understood goal of any research program.

Strand 6: Science Learning in Informal Contexts

Informal Science Educators' Perspectives on DEI: Implications for Teaching Beyond the Classroom

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ABSTRACT

Informal science spaces, and particularly outdoor science spaces, have historically been spaces that echo systemic discrimination and uphold Whiteness (Gosalvez, 2020). Students from marginalized groups have expressed that they felt informal science experiences were not designed for them (Tal, 2020; Dawson, 2014). Informal Science Institutions need to interrogate the way they design and implement programming through a critical lens and work toward addressing issues of DEI. We need to understand the perspectives of the informal science

educators (ISErs) who implement this programming and who interact with participants. This paper gives preliminary findings from a survey to ISErs in a large midwestern state. I found that ISErs cared greatly about increasing participants' feelings of belonging, but they felt their organizations were either unprepared to do so or were resistant to such change. Although ISErs have opportunities for trainings and meetings related to DEI, many are unsure of how to implement what they learned or feel there are programmatic barriers to implementing these changes. From these findings, we may be able to address some of the barriers ISErs mentioned and to figure out what supports they need to enact the change they wish to see.

Strand 6: Science Learning in Informal Contexts

"I prefer gaming": Engaging young children in coding in an out-of-school STEAM-enriched programme

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Mónica López López, University of Groningen, Netherlands

ABSTRACT

The importance of technology in STEM education is critical in assisting young people in developing strong computational abilities, which are not only taught in the classroom but also offered in after-school programs. To bridge the gender gap in computational sciences, informal educators should consider the experiences of young girls and their representation in the programs when developing curricula and delivering instruction. The goal of this presentation is to show how young children's engagement in coding nurtures their science identity development. Children in a STEAM program (science, technology, engineering/environment, arts, and mathematics) participated in a variety of activities, including block-building coding with Scratch. The classes demonstrate how to engage young children and discover their interests, as well as introduce them to coding and provide a means for those who already code to develop their own games.

Strand 7: Pre-service Science Teacher Education

Interdisciplinary Pre-service Teacher Training

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Berta Barquero, University of Barcelona, Spain
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ABSTRACT

The present project is a result of a collaboration of research groups of five European academic institutions specialised in science, mathematics and computer science education. The project aims to the design and development of interdisciplinary teaching modules for pre-service teacher training in advanced STEM topics, as well as in curricular interdisciplinary topics. In particular, theoretical constructs from the literature such as the boundary objects framework and the typologies of interdisciplinarity are been implemented as ‘lenses' in order to emphasise the interactions between the disciplines in the activities. In this paper, we present the design of the project and the outputs, i.e. the developed modules which have been developed and tested in cross-national preservice teacher educational contexts.

Strand 7: Pre-service Science Teacher Education

Implementation of Site-based Middle Grades Physical Science Methods Courses: Lessons Learned over a 6-year Period

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Shaughnessy McCann, University of Georgia, USA
David Jackson, University of Georgia, USA

ABSTRACT

Most introductory science teacher education courses face the great disadvantage of not having regular contact with current teachers and students, and the perspectives on practical realities that they can contribute. Yet a combination of factors often prevent "site-based" courses that provide valuable initial field experiences from fulfilling what many stakeholders perceive to be their great potential.

This presentation incorporates "lessons learned" from the perspectives of three different stakeholders (middle school science teacher, former science teacher at the same school and now doctoral student, university professor of science education) on the experience, over a six-year period, of a collaborative effort to create, sustain, and iteratively improve a Middle Grades Physical Science Methods course for prospective teachers in the context of 8th Grade classrooms in a public, urban, Title I middle school.

Our general theoretical goal was to establish a legitimate "third space" (cf. Vick, 2017, 2018) professional and educational environment, characterized by "an equal and more dialectical relationship between academic and practitioner knowledge in support of student teacher learning" (Zeichner, 2010, p. 92).

This presentation distills the results of our most recent experiences into a concise set of practical recommendations emerging from extensive reflective consideration and discussion among the three coauthors.

Strand 7: Pre-service Science Teacher Education

Using Service-Learning to Prepare Preservice Elementary Teachers to Support Scientific Research in the Elementary Classroom

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ABSTRACT

Preservice elementary teachers enrolled in an introduction to scientific inquiry course were provided multiple opportunities to engage in service-learning through partnerships with an urban magnet elementary STEM school and a regional science fair. In the latter, the preservice teachers were provided the opportunity to organize, facilitate, and judge projects in grades K-3. Qualitative analysis of post-fair structured reflection reveals increased self-confidence in the ability to support K-5 student research and confidence in the ability to organize and host a school level fair. The preservice teachers reflected on their interactions with parents, reporting

that parents used science fair as an opportunity to bond with their children and learn about science. Rather than seeing parental involvement as a negative, the preservice teachers recognized the necessity of engaging parents in multiple phases of the students' work. Though concerns about parents doing projects for the students lingered, no instances were observed, reinforcing the notion of science fair as opportunity.

Strand 8: In-service Science Teacher Education

Newly Hired Science Teachers Professional Learning 4.0: A Conceptual Model

Julie Luft*, University of Georiga, USA

ABSTRACT

With an expanding research base on newly hired science teachers, a new conceptual model of early career science teacher learning is needed. This work shares a conceptual model that recognizes newly hired science teachers: have a unique learning to teach experience, learn in ways that allow them to develop professionally, are empowered as they learn, and are embedded within systems that influence their learning. This view of professional learning places newly hired science teacher at the center of the learning experience and recognizes the importance of the highly variable preservice experience in the learning of newly hired teachers. By putting the newly hired science teacher at the center of the learning experience, purposefully composed professional learning opportunities focus on building the personal attributes of newly hired science teachers towards diverse, equitable, and inclusive science instruction. This conceptualization provides guidance to those who collaborate, work, or study with early career or newly hired science teachers. It ultimately suggests a depiction of newly hired science teacher learning that is non-linear, situated in systems, consists of opportunities to learn, and is transformative for the individual teacher, yet focused on equity, diversity, inclusion and a vision of sound science instruction.

Strand 8: In-service Science Teacher Education

Using community tours and mapping to develop a culturally relevant pedagogy

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Joshua Shipman, James Madison High School, USA
Sarah Lucas, State College Area High School, USA
Noah Shultz, Slippery Rock Area High School, USA
Sarah Bevilacqua, State College Area High School, USA
Cassidy Camplese, Dr. Henry A. Wise, Jr. High School, USA
Molly Mowatt, MESA Charter High School, USA
Kevin Toney, Independent, USA
Jonathan McCausland, New Mexico Highlands University, USA
Kathryn Bateman, The Pennsylvania State University, USA

ABSTRACT

With increased focus on equity in science education, many in-service science teachers are becoming familiar with justice-oriented pedagogies like culturally relevant pedagogy (Ladson-Billings, 1995). Unfortunately, teachers may know about culturally relevant pedagogy, but be unsure how to enact it in their teaching practice (Brown et al., 2018). Therefore, study, a collaboration between teachers and researchers, is about how community mapping and tours can help teachers learn to enact culturally relevant pedagogy. Using narrative methods to describe the third iteration of a design-based research study, this study shows how community mapping and tours provided teachers with an authentic avenue to build relationships with students, colleagues, and community members as well as a community of like-minded teachers to develop culturally relevant science units grounded in their experiences with community mapping and tours. This study adds to a growing body of literature on how to support teachers in learning culturally relevant pedagogies and to theorizing what culturally relevant pedagogy can and should look like in science education.

Strand 8: In-service Science Teacher Education

Construction of agency spaces by elementary science teachers in low autonomy curricular environments

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Amanda Magalhães, University of São Paulo, Brazil
Danusa Munford, Federal University of ABC, Brazil

ABSTRACT

In this paper we investigate early stages in the processes of implementation of a new curriculum centered on scientific literacy and inquiry-based science teaching from 1st through 9th grades in schools in Southeast Brazil. We have analyzed discursive interactions during lessons of a six week long in-service Science Teacher Education course in which primary and secondary teachers developed an instrument to analyze and evaluate teachers and students' instructional materials elaborated based on the new curriculum and used this instrument to propose changes before its final implementation in schools. Our aim is to understand the construction of agency spaces when teachers analyze the instructional material used in the implementation of a curriculum reform that is informed by key ideas in science education research. Our analysis shows the tensions between the contexts of curriculum documents, the teachers professional histories, the knowledge available and the classroom practices, evidencing the construction of teacher agency spaces for decision making about the curriculum. (Funding: Grant#2019/16102-3, São Paulo Research Foundation, FAPESP)

Strand 8: In-service Science Teacher Education

Examining Changes in District Science Coordinators' Communities of Practice

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Brooke Whitworth, Clemson University, USA
Julie Luft, University of Georgia, USA

ABSTRACT

District science coordinators (DSCs) are among a group of administrative leaders who are often overlooked in research and professional learning (PL). This study utilized situated learning theory and a Community of Practice (CoP) approach to a two year PL for DSCs. Two groups of DSCs are participating. Group 1 participated in monthly PL sessions over two academic years. Group 2 finished one of two years in the PL. Products from the PL include a strategic plan for science instruction, a curriculum map and evaluation of curriculum, and plans for PL sessions with a supporting evaluation. Other data includes interviews and surveys. Wenger and colleagues (2011) value creation framework was utilized to assess the DSCs' perceptions of value gained from interactions within the CoP. Initial data analysis indicates DSCs may increase value cycle creation over extended participation in the PL. Both groups noted a new sense of confidence in advocating for teachers and understanding NGSS and equitable 3D science teaching practices through collaborative learning within the network. This suggests using a CoP framework for the design of district leader PL may be an effective model and lead to better understanding of challenges through connections and support for positive change.

Strand 8: In-service Science Teacher Education

"The piece that we were looking for": catalyzing lenses for science teachers' equity-centered unit design

Monica Sircar*, Stanford University, USA

ABSTRACT

This qualitative case study follows two high school Teachers of Color who engaged as a teacher-design-team (TDT) to co-plan equity-centered curriculum units for their 9th grade biology course. This paper focuses on their experiences collaboratively designing and teaching two new biology units and explores how the teachers took up conceptions of equity into their curriculum and design process. In these units, the teachers worked to situate student learning in relevant phenomena and issues of social justice, reflecting multifaceted conceptions of equity in science teaching. Teachers reported that (a) shared conceptual lenses on equity and (b) time spent collaboratively mapping the units were critical to meaningfully "interweaving" their goals for equity and science content learning in these new curriculum materials. This case study provides examples of science teachers' multifaceted conceptions of equity as manifested in curricula, as well as illustrates planning structures and conceptual lenses that supported a successful TDT effort to reform science curriculum units to center equity.

Strand 10: Curriculum and Assessment

Using the STEM-OP to explore master teachers' implementation of Naval STEM tasks

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ABSTRACT

Reform promotes enacting interdisciplinary STEM instruction that emphasizes using engineering design to teach science. This shift demands secondary teachers have the pedagogical knowledge and skills to support students' engagement in real-world STEM problems. These goals can be met through purposefully eliciting and leveraging students' STEM ideas and reasoning. However, STEM integration often varies across classrooms. While some variance may be explained by teachers' own classroom adaptations, work is needed to further explore teachers' STEM integration. The current study investigates secondary master STEM teachers' (>8 years STEM teaching) enactment of STEM tasks using the so-called STEM observation protocol, or "STEM-OP". Participants included four middle and high school STEM teachers who were part of a university-school partnership funded by the Office of Naval

Research; developed and implemented a Naval STEM task in their own classrooms. Data were gathered via videotaped observations of teachers' enactment of multi-day STEM tasks; triangulated with lesson plans and semi-structured interview responses. Observations were coded with attention to discrete aspects of STEM integration (e.g., content, context, practices). Findings supported the STEM-OP as a practical and robust method of capturing granular variation in teachers' STEM integration and reflected master teachers' content knowledge and purposeful attention to planning.

Strand 10: Curriculum and Assessment

Measuring Science Teacher Knowledge of Models and Modeling in Science: Development and Validation

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Amanda Hall, North Carolina State University, USA
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ABSTRACT
Next Generation Science Standards science practices are crucial to reformed science teaching and learning. Professional developments (PD) exist for teachers to gain knowledge and skills related to specific practices. Developing instruments that measure gains in teacher knowledge of these science practices is needed to assess any changes as a result of PD and for inferring the interrelatedness of science practices with other variables. The theoretical construct of one practice, developing and using models, has been derived from empirical studies over the past two decades. Using an empirically-derived modeling competence framework, we develop and validate a 25-item multiple choice instrument to measure teacher knowledge of models and modeling in science (KMM-S). The test content of the KMM-S instrument is investigated using subject-matter experts while the internal structure is investigated using Rasch modeling to inquire whether gradations imposed in the items' answer options are equidistant. Findings point to a need to include additional contextual information in the background of the items and the answer options in items suggest gradations are not equidistant. Additional findings indicate science teachers, despite modeling training and experience, may have knowledge of the epistemic use of models and modeling in science, which is contradictory to previous modeling research.

Strand 11: Cultural, Social, and Gender Issues

Teachers Negotiating Professional Vision around Equity through Material Representations

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Nicole Walsh, Cascades High School, USA

ABSTRACT
Science education is still working to achieve equity. In order to more fully realize a vision of equity in science education, we need to attend to historical, political, and moral dimensions of

equity (Morales-Doyle, 2019). Therefore, this study focuses on how one inservice teacher and six preservice teachers attended to equity as they co-planned a science unit. Using professional vision (Goodwin, 1994) to render the community's negotiation of equity visible, we analyzed video recordings of their planning as well as all of the relevant planning documents. Analysis implies that teachers require deep, contextual knowledge to plan for equity that focuses on historical, political, and moral dimensions of equity. Without contextual knowledge, teachers may only focus on canonical science knowledge as a means for equity in science. Finally, our findings suggest that inservice and preservice teachers can benefit from co-planning together as each group of teachers brings helpful perspectives to the table that are important for achieving equity in science education.

Strand 11: Cultural, Social, and Gender Issues

How well do undergraduate biology syllabi address culturally responsive curriculum?

Katie Nolan*, The Pennsylvania State University, USA

ABSTRACT

Science has long been a restrictive field that perpetuates inequalities that most significantly impact women, people of color, low income students, and first generation students. Use of culturally responsive curriculum has been shown to be influential in empowering students that struggle to see themselves in the curriculum (Barron et al., 2020; Milner, 2011; Tzou et al., 2021). Given recent social and political events in the United States, it is more important than ever to evaluate undergraduate biology curriculum and reimagine it with a culturally responsive lens. The purpose of my study was to collect a random sample of undergraduate biology syllabi and assess whether they address the components of a culturally responsive curriculum. The research question I aim to answer is: How do undergraduate biology syllabi address culturally responsive curriculum?

Strand 11: Cultural, Social, and Gender Issues

The Impact of Professional Development on A Physics Teachers Identity Towards Equitable Instruction.

Clausell Mathis*, Michigan State University, USA

ABSTRACT

Our study aims to examine a female secondary physics teacher's identity towards equity as a result of participating in a summer professional development (PD) workshop focused on equitable approaches to energy instruction. The inspiration for this work comes from selected teachers' statements on the impact of the summer PD on their teaching identity. During the summer PD, teachers engaged in discussions on how to develop lessons designed to use students' cultural resources as a way to address socio-political concerns around issues of energy. A qualitative case study of a teacher named Morgan was done where I identified moments where she described aspects of her physics teaching identity towards equity. Our analytical lens of examining Morgan's teacher identity towards equity was inspired by the Culturally Relevant Pedagogy Framework (Ladson - Billings, 1995), focusing on teachers' conceptions of self, others, knowledge, and pedagogy.

Strand 11: Cultural, Social, and Gender Issues

Taking the Lead from Harriet Tubman. Black Women Overcoming STEM Deficits Through Dialogical Relationships.

Teresa Massey*, Georgia State University, USA

ABSTRACT

Varied literature exemplified by Thernstrom and Thernstrom (2004), provides the narrative---African American females have deficits starting as early as elementary school that lead to ill preparedness for and non-participation in STEM careers. Dominant ideologies position non-dominant students as deficient, (Noguera & Wing, 2006; Warren & Rosebery, 2011) rather than focusing on the intelligence that is embedded in them. Collins (2000) contends that Black women can be empowered when intersecting oppressions are eliminated. She (2003) suggests employing dialogical relationships of Black women to consider their collective experiences and group knowledge. Creating a change of narrative within those that are oppressed by the inequalities surrounding STEM may provide a viewpoint that change can be made regardless of the challenges that one faces. Moore (2008) suggests that Black science teachers can use their knowledge and experience to serve as role models and mentor the Black girls that they teach, providing preparedness for STEM careers. This poster presentation proposes that both BFT and positional identity theories can provide understanding to how dialogical relationships between Black female science teachers and the Black girls that they teach can lead to science careers. A qualitative study that addresses the multi-dimensions of Black women and their paths to STEM careers.

Strand 11: Cultural, Social, and Gender Issues

Homeless Students and the Right to Science Education: Lessons learned from Street Schools

Matthias Fischer*, University of Education Heidelberg, Germany
Manuela Welzel-Breuer, University of Education Heidelberg, Germany

ABSTRACT

There are approximately 37000 street youth living in Germany. The difficulties of street youth in mainstream schools show that they often do not receive support and consequently adequate education in the regular school system. In addition to the Sustainable Development Goal "Quality Education", the UN Convention on Human Rights also leads to a right to science education for everyone. To realize these rights for street youth, so-called street schools were founded in Germany. There, they can acquire school diplomas while their special learning conditions and circumstances are considered. The present interview study answers the question which special learning conditions street youths have in science classes and how science teachers and responsible persons of street schools support them regarding their learning conditions. These questions will be answered in depth regarding their difficulties in science classes to accept and sustain learning processes. Therefore, fourteen science teachers and ten responsible persons of ten different German street schools were interviewed. The results clearly show that science education has the potential to sustainably change the academic self-concept of street youth. The presented findings allow conclusion for science education with homeless students not only in Germany.

Poster Session B, 4/20/23, 15:35-16:20

Strand 11: Cultural, Social, and Gender Issues

A bibliometric image of the JRST

Ozgur Dogan*, Marmara University, Turkey

ABSTRACT

As a real time socio-scientific issue, the COVID-19 pandemic has clearly shown us the need for the public to understand science. As experts have repeatedly stressed in recent years, science education plays an important role in developing scientifically literate societies. In this context, it is critical to consider which subjects science educators frequently concentrate on and the messages they give to researchers, policymakers, and other stakeholders. Therefore, the purpose of this study was to use bibliometric data to understand the topics that the articles in the JRST, one of the flagship journals about science education and teaching, focused on over the last 20 years. This study employed both descriptive and bibliometric analysis. Based on data from the Web of Science (WoS), descriptive analyses are presented as frequencies and percentages and we used VOSviewer software for bibliometric analysis. Findings showed that more than 80% of the authors of the JRST are from the US, Australia, Canada, and the United Kingdom. Moreover, results of these analyses demonstrate that the researchers publishing in the JRST focused on two main ideas over the past-20years: "Which science teaching methods and strategies are most effective?" and "What can be done to make science teaching more inclusive?"

Strand 12: Technology for Teaching, Learning, and Research

An Analysis of Resources Available to Guide Teachers' use of Bee-Bots in Early Learning Settings

G. Michael Bowen*, Mount Saint Vincent University, Canada

Eva Knoll, Université du Québec à Montréal, Canada

Amy Willison, Independent Consultant, Canada

ABSTRACT

Various robot and programming technologies are being introduced into primary schools and early learning centres for use by younger children. One type of these technologies, generally described as floor robots, is the Bee-Bot®, which is an easily programmable robot technology intended for early learners. Apart from being able to introduce young learners to aspects of computational thinking, floor robots can also be used as a foundation for teaching subjects such as science, mathematics, and language and literacy. This paper examines resources available for educators interested in learning how to use a Bee-Bot with their students, provides details on what information is available in those resources, and analyzes a subset of them with regard to their complexity regarding the activities for students. Resources reported on in this paper includes websites, blogs, news media articles, Pinterest, YouTube videos, and curriculum resources such as Teachers Pay Teachers and Share My Lessons. Our survey of these resources suggests that although there is a wide variety available in a variety of subject areas, most offer only superficial guidance for using Bee-Bots with early learners and only a minority engage students in depth with the robots.

Strand 12: Technology for Teaching, Learning, and Research

A Task Awareness Approach to the Assessment of Virtual Learning Environments (VLEs)

Rob Monahan*, NC State University, USA
James Minogue*, NC State University, USA
Amanda MacCormac, NC State University, USA
Emily Brunsen, NC State University, USA
Tabitha Peck, Davidson College, USA
David Borland, RENCI, USA

ABSTRACT

Accurately assessing teacher understanding of physics concepts present challenges similar to those faced by teachers assessing student understanding. This is even more complex when a novel virtual learning environment (VLE) is involved. Thus the present study was born out of persistent "issues of assessment" regarding the differential impact of interactive science simulations that incorporate haptic force-feedback. Our poster describes the testing of a haptically-enabled VLE for the teaching of core force and motion concepts and an exploratory "audit" of assessment effectiveness. The work is situated at the intersection of educational technology and assessment. The study involved a convenience sample (N = 27) of undergraduate pre-service teachers. Our analysis was through a "task awareness" lens and showed us that our initial assessment method using the SOLO taxonomy may have underestimated what users gained from their interactions with our VLE. It revealed that the pre-service teachers involved held incomplete understandings of force and motion concepts but with the addition of a second assessment layer we found more sophisticated levels of understandings. In the end, we present a "task awareness heuristic" that holds promise for the creation of assessments of learning in VLEs.

Strand 12: Technology for Teaching, Learning, and Research

Untethering Science Interest from Reading Proficiency: Pilot Results from a Microsoft HoloLens Science Reading Intervention

Denise Bressler*, ETS, USA
Leonard Annetta, East Carolina University, USA
Michael Tutwiler, University of Rhode Island, USA

ABSTRACT

Successful readers show great success within their science classes. But what about struggling readers? Unfortunately, struggling readers have a serious obstacle to overcome to improve their science achievement. One way to help struggling readers is to raise their science interest because interest is related to achievement in various areas of STEM. Studies demonstrate that students reading with virtual enhancements are more motivated and interested. In this study, participants read scientific text while wearing a Microsoft HoloLens which enabled visual enhancements to help readers grasp challenging science content in situ. Data were collected through a pre-test on reading and a pre-post survey on interest. In general, science interest scores increased over the course of the intervention, rising from a mean of 4.0 (sd=1.0) pre-intervention to a mean of 4.4 (sd=0.7) post-intervention. More importantly, about 16% of the variability in pre-intervention science interest was attributable to their reading proficiency, yet

only about 4% of post-intervention science interest was explained by prior reading proficiency. After the intervention, the pre-existing relationship between reading proficiency and science interest became untethered, largely because students with lower initial science interest (primarily the struggling readers) reported an increase in science interest after reading scientific text with the HoloLens.

Strand 12: Technology for Teaching, Learning, and Research

Quickstart Spaceship Programming for Developing Physical Intuition

Jacob Kelter*, Northwestern University, USA
Amanda Peel, Northwestern University, USA
Bradley Davey, Northwestern University, USA
Michael Horn, Northwestern University, USA
Uri Wilensky, Northwestern University, USA

ABSTRACT

Decades of research show that students enter the physics classroom with non-Newtonian intuitions and that changing these intuitions is difficult. To help students build their Newtonian intuitions we designed a Constructionist microworld with an embedded "quickstart programming environment." A quickstart environment uses block-based programming, but the blocks represent important concepts or mechanisms in a science domain rather than low-level computational primitives. This enables students to learn about scientific phenomena through programming without needing any prior programming experience. In our microworld, students program the engines of a spaceship to turn on and off with the goal of getting the spaceship to a target area. We qualitatively analyze video data and the sequence of programming blocks used by a pair of students to show how their mental models diverged and converged and ultimately aligned with the physics ideas embodied in the microworld. This type quickstart programming environment for physics can be a powerful way of helping students develop their physical intuitions while also engaging in programming and computational thinking.

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

The Intersection of NOS and NGSS: A High School Science Educator's Perspective

Mary Johnston*, Indiana University, USA
Valerie Akerson, Indiana University, USA

ABSTRACT

The dissemination of nature of science (NOS) and incorporation of Next Generation Science Standards (NGSS) are intended to enrich science education and create informed citizens (Lead States, 2013a, Lederman, 2010; National Science Teacher Association (NSTA), 2021). NGSS presents eight categories reflecting NOS, derived from Scientific and Engineering Practices (SEP's) and Cross Cutting Concepts (CCC's), in its Appendix H. Established methods for the effective delivery of NOS within the classroom require the explicit and reflective embedding of tenets within content; the three dimensional NGSS framework is less specific about both method and pedagogical techniques (Authors, 2000; Lederman, 2016). The purpose of the concurrent action research / self-study was to determine the impact grade level exemplars listed for each of the eight categories of Appendix H as a resource for the explicit and reflective

embedding of NOS tenets within a unit lesson on the gas laws. Pre-interventional and post-interventional VNOS-B questionnaires, as well as field notes and instructor reflections were coded or analyzed to determine the impact of the revised unit lesson. The inclusion of NOS via explicit and reflective embedding of tenets within NGSS lessons via Appendix H was beneficial to both the students and educator and warrants further research.

Strand 14: Environmental Education and Sustainability

Healing Relationships with the Natural World Through Critical Place Inquiry

Alexandra Schindel*, University at Buffalo-SUNY, USA
Ryan Rish, University at Buffalo-SUNY, USA
Kellyann Ramdath, University at Buffalo-SUNY, USA
Dave Mawer, University at Buffalo-SUNY, USA
Kendra Ormerod, University at Buffalo-SUNY, USA

ABSTRACT
How are environmental and science educators engaging with the complex task of understanding and teaching about climate justice in a time of climate crisis? We have instead felt compelled to begin the practice of teaching climate justice in education to pre-service teachers and to engage in research to explore the implications of our work. The approach we put forth in this paper is one that investigates climate justice conceptually and experientially through explorations with others, with the natural world, and within places that are meaningful to learners. First, we share background on climate justice and place-based science learning. Following this, we theorize the concept of placemaking to explore the complexities of engaging in sensemaking of particular places (i.e. geographic locales). Following this we draw upon evidence from a climate justice in education course. We propose engaging pre-service teachers in "critical place inquiry" as a pedagogic tool for engaging in the praxis of healing our relationships through "seeing" the dynamic social, historical, and political landscape of places and all its inhabitants.

Strand 14: Environmental Education and Sustainability

Community Science Data Talks: The Intersection of Justice, Emotion, and Place

Imogen Herrick*, University of Southern California, USA
Michael Lawson, Kansas State University, USA
Ananya Matewos, St. Norbert College, USA

ABSTRACT
Community Science Data Talks (CSDTs) are a classroom practice that supports students' understanding and hopefulness about complex environmental justice-related issues through scaffolded classroom conversations. This study aims to understand teacher experiences planning, implementing, and reflecting on CSDTs when tasked to explicitly plan and attend to dominant, critical and affective goals. To examine this purpose, we used a phenomenological inquiry approach to analyze teachers' pre/post-interviews, focus groups, and professional development sessions in order to answer the following research question: How do teachers, across disciplines and grade levels, negotiate their instruction on CSDTs when planning for dominant, critical and affective pedagogical goals? Findings indicate that teachers

overwhelmingly found participating in professional development and implementing CSDTs fruitful for themselves and their students. Specifically, we found four themes that describe how teachers negotiated CSDTs: intentional planning structures for the future, affective pedagogical goals as generative, deep emotions equal deep conceptions, and the entanglement between emotion and place. Overall, we recommend that science educators engage students in science learning through their lived experiences. Furthermore, approaches, such as CSDTs, afford teachers and researchers unique insights into students' funds of knowledge that can help leverage a sense of place often missing in science instruction.

Strand 14: Environmental Education and Sustainability

Pre-service Teachers' Plausibility Perceptions of Global Climate Change: Results of the updated Plausibility Perception Measure

Melike Hanedar*, Bogazici University, Turkey
Gizem Ozyazici*, Bogazici University, Turkey
Gaye Ceyhan, Bogazici University, Turkey

ABSTRACT

Climate crisis is a vital environmental issue that every citizen needs to be concerned about. Therefore, this study aims to examine pre-service teachers' plausibility perceptions of climate change. In this study, we updated the Plausibility Perception Measure (PPM) scale (Lombardi & Sinatra, 2012) according to the latest IPCC report in 2022. According to the IPCC report in 2022, 3 main factors were determined, which are observed and projected impacts and risks, adaptation measures and enabling conditions, and climate resilient development (IPCC, 2022). The updated PPM scale is a ten-point Likert scale consisting of 15 items. Data were collected from 109 pre-service teachers in a public research university. The reliability of the scale represents an excellent consistency measure (_=.93). The results of the confirmatory factor analysis revealed that three-factor model had a good fit for the data (TLI ≥ .90, CFI ≥ .90, RMSEA ≤ .08). Among the factors, participants rated factor 1 as the highest plausible whereas participants rated factor 2 as the lowest plausible.

Strand 15: Policy, Reform, and Program Evaluation

A Framework for K-12 Classroom-Based Opportunity to Learn in Science

Dante Cisterna*, ETS, USA
Farah Qureshi, ETS, USA

ABSTRACT

This study conceptualizes and proposes a framework for the construct of opportunities to learn (OTL) in K-12 science education at the classroom-based level. Measuring classroom-based OTL in science education is important to determine which resources and learning experiences students have access to. From an equity perspective, measures of classroom-based OTL can be used to ensure that all students, regardless of their backgrounds and identities, are given meaningful opportunities to learn science—including opportunities to engage in scientific practices. We aim to characterize the components that can be potentially measured by collecting information from students, teachers, and classrooms. Drawing on a review of research and practitioner literature, we identified and described the components for classroom-

based OTL. Two areas that make up classroom-based OTL were identified: (1) access to classroom-based resources and (2) opportunities for relevant instruction and student participation. Through the characterization of the framework components, we highlight that classroom-based OTL does not only imply providing access to resources but also ensuring that all students, regardless of their backgrounds can participate in science communities. We discuss the implications of this framework for identifying and measuring OTL and identifying future areas of research and development.

Strand 15: Policy, Reform, and Program Evaluation

Rural Administrators and STEM Education: Their Perceptions and Decision-Making

Devan Jones*, Clemson University, USA
Julianne Wenner, Clemson University, USA

ABSTRACT

More than 9.3 million students in the U.S. attend rural schools (Showalter et al., 2019). Yet, as Saw and Agger (2021) note, the bulk of research and policy addressing STEM opportunity and access has paid little attention to those in rural locales. This qualitative exploratory study sought to hear the voices of rural administrators and their perspectives on STEM. For the purposes of this research study, STEM is defined as Science, Technology, Engineering, and Mathematics that links applications in content areas and disciplines within cross-curricular educational settings. Since there is no clear definition for STEM, stakeholders often turn STEM into what they want it to be (Assefa & Rorissa, 2013). The methods presented here describe data analysis for preliminary findings; further analysis will be conducted prior to the presentation. Participants for the study were initially identified via personal contacts. Participants were required to be current administrators (principals, assistant principals, and superintendents) in rural public school systems. Using Bronfenbrenner ecological systems theory we intend to use thematic content analysis to learn more about rural administrators' perceptions of and decision-making around STEM and consequently the consideration the various components of the ecosystems.

Concurrent Session 10
4/20/23, 16:30-18:00

Asian and Pacific Islander Science Education Research (APISER) Sponsored Session: Science Education Research Involving Learners of Asian And Pacific Islander (API) Heritage
4/20/23, 16:30-18:00, Salon A4 (LL)

Science Education Research Involving Learners of Asian And Pacific Islander (API) Heritage

ORGANIZERS
Ling Liang, La Salle University, Philadelphia, PA, USA
Xiufeng Liu, University at Buffalo, State University of New York, NY, USA
Xinying Yin, California State University-San Bernardino, CA, USA

PANELISTS
Pauline Chinn, University of Hawaii at Manoa, USA
Jennifer Tripp, University at Buffalo, SUNY, USA
Lei Liu, Educational Testing Service, USA
Mihwa Park, Texas Tech University, USA

ABSTRACT
The symposium aims to provide a platform for NARST members to share their perspectives and experiences in science education research involving learners of Asian and pacific islander (API) heritage. The panelists will discuss culturally relevant issues in science curriculum, learning, teaching, assessment or evaluation, educational leadership, and policy issues in both K-16 formal and informal educational contexts. The session participants will also have an opportunity to share their own stories and concerns, and explore possibilities to tackle some issues of common interests through collaborative research.

Latino/a RIG (LARIG) Sponsored Session: Voices from Latinas: making sense of research
4/20/23, 16:30-18:00, Salon C3-4 (LL)

Voices from Latinas: making sense of research

ORGANIZERS
Angela Chapman, University of Texas Rio Grande Valley, Edinburg, TX, USA
Alejandro Gallard, Georgia Southern University, Statesboro, GA, USA

Concurrent Session 10, 4/20/23, 16:30-18:00

PANELISTS
Gianna Colson, University of Texas Rio Grande Valley, Edinburg, TX, USA
Miriam Ortiz, University of Texas Rio Grande Valley, Edinburg, TX, USA
Ruth Colyer, University of Texas Rio Grande Valley, Edinburg, TX, USA
Angela Chapman, University of Texas Rio Grande Valley, Edinburg, TX, USA

ABSTRACT
This purpose of this administrative session is to provide a space for science educators and scholars to actively engage in critical dialogue and discussion to further and support Latino/a scholarship. We will share research on Latina"s perceptions of who can do science, through the voices and narratives of three Latina doctoral students and Latino STEM educators. Their experiences and insights will be central to a discussion regarding findings regarding K-12 Latina"s perceptions of scientists. Counter stories and a CMF framework helped to shed light on how Latinas perceive who can do science. By exploring their lived experiences through the intersection of race, ethnicity, gender, and class we found that CMFs and limit-situations created an ecosystem for Latinas to navigate their way to success in science. The session will provide a better understanding of these phenomena, and the findings can inform approaches to designing and conducting LARIG related research.

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set: Learning Progressions in Science Education Research
4/20/23, 16:30-18:00, Salon C7-8 (LL)

Development and Refinement of Learning Progressions for Fundamental Constructs of Mechanical Waves

Maria Veronica Torralba*, De La Salle University, Philippines
Frederick Talaue, De La Salle University, Philippines
Maricar Prudente, De La Salle University, Philippines

ABSTRACT
Refinement of curriculum for coherence can benefit from studies of learning progressions, which are descriptions of students' understanding of a topic at increasing levels of sophistication. Learning progressions can also provide insights on logical sequence of instruction that would facilitate students' construction of knowledge as well as specifications for assessing at which stage the students are in the learning process. Regardless of how learning progressions vary in scope of content, grain-size, and time span, they are grounded on research about how students learn concepts in a discipline and they can be empirically tested. In this study, hypothetical learning progressions for constructs of wave propagation on a string, wave reflection on a string, wave refraction in water, and wave superposition were developed after conducting a systematic review of studies on student understanding of mechanical waves. To verify the proposed learning progressions, an assessment instrument was developed by constructing dichotomously scored test items with each item corresponding to a particular level in the hypothetical learning progression. This test was administered to

secondary school students and results were analyzed using the Rasch model. Comparison of test item difficulty obtained through Rasch analysis was then used as a basis for revising the learning progressions.

Investigation of a chemistry_specific learning progression for upper secondary school

Erika Knack*, University of Duisburg-Essen, Germany
Vanessa Fischer, University of Duisburg-Essen, Germany
Maik Walpuski, University of Duisburg-Essen, Germany

ABSTRACT

Cumulative learning is central for the development of integrated chemical knowledge (Fischer et al., 2006). However, studies in the field of chemistry show that students' knowledge is very heterogeneous (e.g. Hailikari & Nevgi, 2010). Therefore, it can be assumed that students often lack a systematic knowledge structure. Learning progressions describe competence development processes and indicate a possible sequence of concepts to be acquired over a period of time (Duschl et al., 2007). Thus, they can be used as possible instruments to support cumulative learning. However, previous studies in the field of chemistry education usually focus on examining knowledge development at lower secondary level and in tertiary education, resulting in a lack of studies for upper secondary education. In order to address upper secondary education, we developed a chemistry-specific learning progression for upper secondary school. To validate the content of the learning progression and the assumed dependencies between the concepts, it was evaluated by an expert group (N = 7). Additionally, an assessment test according to the learning progression was developed to validate the learning progression empirically. First results of the study show that there is strong vertical interconnectedness between the chemical concepts, while the horizontal interconnectedness is less pronounced.

Investigating a Learning Progression for Particle Nature of Matter from Upper Elementary Through High School

Xiuhong Wang*, Northeast Normal University, China
Tingting Li*, Michigan State University, USA
Peng He, Michigan State University, USA
Joseph Krajcik, Michigan State University, USA

ABSTRACT

Learning progressions (LPs) play a pivotal role in promoting teaching and learning, which play a pivotal role in promoting teaching and learning, especially given its potential to enhance coherence in curriculum, instruction, and assessment systems. However, most existing studies only focus on one or two school levels and are mainly situated in western countries. This study explores students' learning trajectories of the particle nature of matter (PNM) across upper elementary to high school in non-western countries, which may bring new perspectives to the existing LP studies. We developed an initial LP based on prior research and an instrument (PNMPA) to validate the LP. Grade 6-12 students (N = 1,237) from eight high schools across western, northern, central, and southern parts of Mainland China took part in the main study.

We conducted Rasch analysis to validate the instrument and the PNM LP. Preliminary findings were reported.

A Learning Progression for Water as a Limited Resource and Human Impacts within Socioecological Systems

Kristin Gunckel*, University of Arizona, USA
Malissa Hubbard, University of Arizona, USA
Sean Tan, University of California Berkeley, USA
Dan Moreno, University of Arizona, USA
Mingfeng Xu, University of California Berkeley, USA
Linda Morell, University of California Berkeley, USA
Mark Wilson, University of California Berkeley, USA

ABSTRACT

Although there is research on student understanding of the water cycle, there are few resources for assessing student learning about the ways that socio-cultural-political systems impact the availability and quality of water. This paper presents the development of learning progressions for students' understanding of water as a natural resource (NR) and the impact of human activities on water within socioecological systems (HI). The research involved developing construct maps to describe qualitatively different levels of student understanding of NR and HI. Open response assessment items aligned with each construct map were written and administered to 891 middle school students in three states. Scoring rubrics were created and student responses were scored based on the construct map. Scores were modeled using a 2-dimensional, partial credit Rasch model and a Wright map was produced. Results show that the construct maps for NR and HI were highly correlated (.813) but distinct. The Wright map shows four levels of performance. Most students reached level 2, suggesting few students have opportunities to learn about how human activities impact the availability of water within socioecological systems. This research will be useful for building curriculum and instruction to support students in making sense of water-related issues.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Student Learning and Cognition
4/20/23, 16:30-18:00, Salon C5-6 (LL)

The Role of Cognitive Engagement, Learning Enjoyment, and Epistemology Belief in Building Undergraduates' Science Learning

Hsin-Hui Wang*, National Sun Yat-sen University, Taiwan
Huann-shyang Lin, National Sun Yat-sen University, Taiwan
Zuway-R Hong, Kaohsiung Medical University, Taiwan
Ling Lee, National Sun Yat-sen University, Taiwan

ABSTRACT
The purpose of this study is to explore how the cognitive engagement, enjoyment of learning science, and epistemology belief related to undergraduate students' performance in history of science, system thinking, and inquiry. Ninety (n=90) Taiwanese undergraduate students participated in a semester-long course of teaching intervention. Partial least squares structural equation modelling (PLS-SEM) results demonstrated that the most important factor affecting undergraduate students' learning performance is their cognitive engagement, as it positively and significantly predicts three types of learning performance: history of science ($\beta = 0.413$, $p < .001$), system thinking ($\beta = 0.475$, $p < .001$), and inquiry ($\beta = 0.264$, $p = .010$). In addition, we also found that undergraduate students' enjoyment of learning science was positively and significantly predicted their learning performance of inquiry ($\beta = 0.342$, $p = .002$), and epistemology belief was positively and significantly predicted their learning performance of system thinking ($\beta = 0.221$, $p = .050$). Educational implications and recommendations are discussed. Keywords: cognitive engagement; enjoyment; epistemology belief; science learning

Navigation of personal and disciplinary values in an undergraduate computational biology course

Sugat Dabholkar*, Tufts University, USA
Julia Gouvea, Tufts University, USA
Lawrence Uricchio, Tufts University, USA

ABSTRACT
Understanding students' navigation of personal values and interpreted disciplinary values is essential to supporting their disciplinary identity development. Even though STEM courses are increasingly being designed to support the participation of underrepresented students, little work is done to understand how students from marginalized groups navigate disciplinary values. In this paper, we study how undergraduate students in a computational biology course navigated disciplinary values and how specific design features of the course supported their navigation. We present a qualitative analysis of two student interviews focusing on how the course supported them differently in navigating tensions and finding alignments between their personal values and interpreted disciplinary values. The findings yield implications for studying and supporting students' value navigation in science learning environments

Systematic Review on Learning in STEM Education With More Than Two Visual Representations

Eva Rexigel*, Technische Universität Kaiserslautern, Germany
Sarah Malone, Saarland University, Germany
Sebastian Becker-Genschow, University of Cologne, Germany
Jochen Kuhn, Ludwig-Maximilians-Universität, Germany

ABSTRACT
Science education is highly characterized by interacting with different symbolic (e.g., tables, equations, and formulas) and graphical representations (e.g., graphs or pictures). There is a broad range of current research showing that learning of scientific content can be improved by presenting multiple external representations (MER). Current synthesis on learning with MER

mainly focus on representational combinations of two visual representations though, commonly text and picture. To fill this gap, we conducted a systematic review on learning with MER in science, technology, engineering, and mathematics (STEM) education, focusing on combinations of at least three representations. The research question is how number, and type of combined representations relate to cognitive load and conceptual knowledge, as two main cognitive learner variables. Based on a systematic search (N=10,821 results) we identified N=26 relevant studies. Results indicate that current studies mainly focus on learning settings comprising maximum three visual representations. Furthermore, combinations of solely symbolic or graphical representations are predominantly ignored. The reviewed research reveals potential to reduce extraneous cognitive load and improve students conceptual understanding in presenting more than two representations, especially when providing syntactic or semantic support. Findings regarding specific variations in number and type of representations are contextualized and discussed.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Special Topics in Chemistry Education Research
4/20/23, 16:30-18:00, PDR 2 (L3)

Systematizing student difficulties in organic chemistry as a basis for developing adaptive support

Gyde Asmussen*, IPN - Leibniz Institute for Science and Mathematics Education, Germany
Marc Rodemer*, University of Duisburg-Essen, Germany
Sascha Bernholt, IPN - Leibniz Institute for Science and Mathematics Education, Germany

ABSTRACT
Problem-solving is challenging for students in organic chemistry. In addition to studies reporting on multiple student difficulties in dealing with organic reaction mechanisms, a variety of suggestions exist on how to support students. In our research, we classified students' difficulties in dealing with organic reaction mechanisms using Bloom's revised taxonomy to draw specific conclusions about the design of the intended support. An interview study on reaction mechanism tasks was conducted with undergraduate chemistry students. The classification of difficulties encountered shows a wide distribution across the taxonomy and across students. Since students' difficulties vary in nature, there are differentiated support requirements for individual students. Our analysis suggests that students may benefit more from adapted support than from general support. Derived from this result, we developed support for each cell of the taxonomy. Using Bloom's revised taxonomy to classify student difficulties might also be of benefit in other domains to better understand student difficulties and provide appropriate support. In a second interview study, we provided the developed support adaptively to students during problem solving. Students' use of this adaptive support and its effectiveness will be further investigated.

Supporting First-Year Students in Learning MO Theory through a Digital-Collaborative Intervention

David Hauck*, TU Dortmund University, Germany
Andreas Steffen, TU Dortmund University, Germany
Insa Melle, TU Dortmund University, Germany

ABSTRACT

Quantum theories of chemical bonding such as molecular orbital (MO) theory are among the most difficult content that chemistry students have to learn during their studies. The necessary foundations for the subject are often laid in the first semesters, posing great challenges for the students. Many chemistry students drop out of their studies because they cannot meet the high demands, especially when they enter university with insufficient fundamental prior knowledge from school. These problems are reinforced when students feel socially isolated in times of online lectures during the COVID-19 pandemic. Against this background, we developed, implemented, and evaluated a digital-collaborative intervention study to support and connect students of chemistry, and chemistry education in the first semester at our university. Here, the students first worked with interactive learning videos and then created concept maps in which they linked central concepts of MO theory.

As part of the study, the students' subject knowledge was assessed before, after and during the intervention. Our results show that students were able to significantly improve over the course of the intervention, especially if they started with low or average prior knowledge. Additionally, three different forms of structuring the two intervention phases are compared in this paper.

PS-I Instructional Approach's Effects on Transfer of Learning from an AOT perspective: A Case Study

Cheng-Wen He*, University of Georgia, USA
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ABSTRACT

This study investigated how a preparatory problem-solving activity preceding instruction (PS-I) approach influenced a learner's transfer of learning from an actor-oriented (a learner's) transfer perspective (AOT perspective). The positive impact of the PS-I approach on conceptual understanding and transfer can be attributed to several key cognitive and socioemotional mechanisms. However, prior PS-I research has exclusively focused on observer-oriented transfer, so we do not know how the PS-I approach might result in unanticipated, actor-oriented forms of transfer. This paper adopted a case study approach and used think-aloud and semi-structured interview data to explore the unpredicted affordances of the PS-I approach on an undergraduate's learning of noncovalent interactions. Our findings show that the learner leveraged two normative knowledge elements during the problem-solving phase and subsequent near-transfer problem solving. Furthermore, the learner-generated connections between these two knowledge elements developed during the problem-solving phase, the near-transfer problem, and the far-transfer problem. This suggests that the preparatory problem-solving phase might facilitate learner-generated connections among knowledge

elements, preparing the learner to transfer their learning to subsequent problem solving. In short, the AOT perspective allowed us to discover unpredicted learner-generated connections that would have been missed through the traditional transfer assessment and perspective.

Facilitation practices of learning assistants in synchronous hybrid college courses

Nicolette Maggiore*, Tufts University, USA
Jessica Karch, Tufts University, USA
Ira Caspari-Gnann, Tufts University, USA

ABSTRACT

Learning environments are vastly different across in-person and remote instruction. In undergraduate STEM courses, learning assistants (LAs) have been working in both settings, however, little is known about how the affordances and constraints of each setting influence LA facilitation practices in small group interactions. Thus, in our study, we explore the ways different contextual factors act as drivers of LA actions in both contexts of a hybrid course, and how these LA actions influence student in-the-moment learning. To do so, we recorded LA-student interactions and conducted interviews with the professor and LAs of a hybrid general chemistry course. We used a sociocultural perspective to provide an explanatory account for the drivers of action on LA facilitation practices and student learning, which revealed the following: When LA purposes/goals and social context were the same, but the conditions and means by which they could enact these purposes/goals were different between the in-person and remote conditions, LAs took different actions in each setting resulting in differences with respect to student in-the-moment learning. With our examples, we present evidence that there are multiple conditional factors that drive LA actions during LA-student interactions. Implications for theory and reform of practice will be discussed.

Strand 7: Pre-service Science Teacher Education

SC-Organized Paper Set: Developing inquiry skills in pre-service science teacher education

4/20/23, 16:30-18:00, Salon A1 (LL)

Developing Global Science Knowledge and Global Competence Skills of Preservice Teachers in a Content Course

Shukufe Rahman*, Indiana University, USA
Conghui Liu*, Indiana University, USA
Gayle Buck, Indiana University, USA

ABSTRACT

Developing elementary science teachers who can foster their students' global scientific knowledge and global competence skills is a worthy goal of science teacher programs worldwide. Unfortunately, the attainment of this goal is hampered by the fact that many teachers lack opportunities to develop this knowledge and skills before entering their first teaching positions. This action research study focused on adjusting an undergraduate science

content course for preservice to foster greater global scientific knowledge and competency skills. The adjustment incorporated opportunities for the preservice to examine and identify the connections between local and international environmental issues. Results show that adding connections between local and global issues benefits the development of global scientific knowledge and the practice of global competence skills. However, students tended to think from one perspective without explicit guidance. The findings indicate that the connections need to be further emphasized, and more global science instructional strategies must be developed.

Pre-Service Primary School Teachers' Understanding of the Distinction Between Observations and Inferences in Science

Shingo Uchinokura*, Kagoshima University, Japan
Kenya Momohara, Kagoshima University, Japan
Nana Yamanaka, Kagoshima University, Japan

ABSTRACT

This study examined pre-service primary school teachers' understanding of a distinction between observations and inferences in science through the online questionnaire with both contextualized and decontextualized questions. The participants were 120 undergraduate students (44 males and 76 females) from a university in Japan. Thirteen students majored in science, while 107 majored in other academic fields. The students understood that observations are statements about facts, while inferences are statements about opinions, regardless of the difference in academic fields In some cases, they considered inferences as observations. Conversely, pre-service teachers seemed to understand observations but stated only their inferences without referring to any connections with observations when making an argument. Therefore, their explanations were seen as guessing and evaluated as inadequate. In addition, the study results showed that the students might lack ideas about the uncertainty of data. The study implicated that pre-service primary school teachers should be taught the construction of a scientific argument in an explicit way, along with learning the Nature of Science. This study was limited in that it examined pre-service teachers' understanding of the inferential nature of science in a familiar context. Further study on the different aspects of the Nature of Science will be needed.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Research and Insights on Approaches About Science Teachers' Instructional Practices
4/20/23, 16:30-18:00, Waldorf (L3)

Prospective Science Teachers' Visions of Scientific Inquiry and Practices, a New Curriculum in Taiwan

Shiang-Yao Liu*, National Taiwan Normal University, Taiwan
Ping-Yi Chou, Hwa-Gang Junior High School, Taiwan

ABSTRACT
Science curriculum reform has occurred in Taiwan in the past few years that engenders a compulsory course named "Natural Science Inquiry and Practices". Relevant teaching methods courses have also been established accordingly. This research was conducted with 13 prospective science teachers in a teacher education institution to explore their perspectives on the new curriculum. The semi-structured interviews aimed to elicit the participants' understandings of scientific inquiry and practices, reflections on the teaching method course, and evaluations of their own abilities to implement the new curriculum. Most participants tended to have a shared view of the definition of inquiry and practice in science curriculum that inquiry is thinking and practice is doing, while their interpretations of the relationship between inquiry and practice are quite diverse. They recognized the differences between I&P activities and cook-book experiments, but struggled with uncertainty in deciding the topics of inquiry and lacked a strategic imagination of how to guide students to achieve the learning objectives that are stated in the curriculum guidelines. The findings of this interview study have been effectively applied in designing the teaching method course that is aimed to build prospective science teachers' visions for implementing the new curriculum.

Science Teacher Educators' Collective Inquiry into Practice for Transforming Preservice Teacher Education In South Korea

Hyekeoung Lee*, Seoul National University, Korea, Republic of
Hosun Kang, University of Califonia Irvine, USA
Gyoungho Lee, Seoul National University, Korea, Republic of

ABSTRACT
Across the world there is an increasing need for well-prepared science teachers who can adaptively design and facilitate powerful science learning for youths in a dramatically changing society. In this project six science teacher educators and researchers in South Korea engaged in a collective inquiry into their practices for five months. Employing participatory design research (Bang & Vossoughi, 2016), we explore how the collective inquiry works toward transforming the curriculum and pedagogy of preservice science teacher education in contexts. Data included interview transcripts, video-recordings, and various artifacts generated from the collective inquiry. The analyses revealed the moments in which differences among teacher educators were surfaced and challenged. Specifically, the activity of co-constructing the principles for designing preservice science teachers' learning experiences created rich opportunities for the participants to notice the nuanced but important differences in each teacher educator's vision and practices. Participants' increasing awareness about the complexity of preservice teacher education and the lack of shared vision led them to begin two new initiatives: starting a research group that studies preservice teacher education and officially demanding for institutionalizing such collective inquiry spaces. The affordances of collective inquiry in transforming preservice teacher education are discussed. Keyword: preservice teacher education, collective inquiry

Effect of practicum course on science instructional practices of pre-service science teachers
Iyad Dkeidek*, Al-Quds University, Palestine

ABSTRACT
Teachers often implement dated instructional practices when teaching. There has been considerable research into the effects of teacher preparation programs on pre-service science teachers' instructional practices. Specifically, how do the various programs influence the strategies that pre-service science teachers use when teaching science, and how do these strategies develop and change? We examined the efficacy of an interactive practicum course that is an important component of a science teacher preparation program for elementary-school science teachers. This program lasted one academic year and involved interactions among three parties: a pre-service science teacher, an in-service science tutor, and an academic supervisor. We used a mixed-methods approach involving self-administered questionnaires, real-time classroom observations, and semi-structured interviews to address 1) How pre-service science teachers' instructional practices were influenced following participation in the interactive practicum course; 2) To what extent are pre-service science teachers' instructional practices aligned with the Portfolio of Lesson Plans published recently by Israeli Ministry of Education and the spirit of the Next Generation Science Standards (NGSS). The results of the current study indicated that the interactive practicum course helped the pre-service elementary science teachers shift from traditional teacher-centered science instructional practices to more modern student-centered practices.

Preservice Science Teachers' Self-Regulated Learning Practice While Planning and Enacting Classroom Questions
Hong Tran*, University of Georgia, USA
Daniel Capps, University of Georgia, USA
Timothy Cleary, Rutgers, The State University of New Jersey, USA

ABSTRACT
This multi-case study investigates preservice science teachers' (PSTs) self-regulation of teaching. The participants were three PSTs representing high, intermediate, and low self-regulated learners in a certification program for teaching secondary science. The teacher questioning data and self-regulated learning (SRL) data came from classroom materials,semi-structured interviews about planning questions, classroom observations, classroom audio recordings, and semi-structured interviews about enacting the questions. Findings show that the PST who was better at self-regulating planning questions was also better at enacting questions. Similarly, the PST who was better at self-regulating planning and enacting questions asked a greater number of higher-cognitive level questions. In addition, the PST who asked the lowest number of higher-cognitive level questions were not good at self-monitoring. The research shows fostering PSTs' SRL skills should help improve their questioning competency.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Science Teachers' Efforts to Design and Implement Innovative Science Lessons
4/20/23, 16:30-18:00, Salon A3 (LL)

Science Teacher Lesson Planning: A Preliminary Study of Acquisition, Selection, and Modification

Joe DeLuca*, University of Georgia, USA
Julie Luft, University of Georgia, USA
Elizabeth Ayano, University of Georgia, USA

ABSTRACT
A preliminary study was conducted to identify where science teachers' lessons originate (e.g., from a colleague, school, published source, self-created, etc.) and the influences impacting how teachers choose and modify instructional resources. A quantitative approach was used to identify where K-12 science teachers' plans originated, and a significant difference was observed between where novice teachers (0-5 years experience) and experienced teachers' lessons originated, X2 (3, N = 212) = 27.05, p = p < .01. Novice teachers were more likely to get their lessons from colleagues and less likely to get them from a published source, whereas experienced teachers were less likely to get lessons from colleagues and more likely to get them from a published source. A thematic analysis of focus groups resulted in three themes regarding influences impacting how teachers choose and modify instructional resources: 1) some science teachers have limited access to instructional resources, 2) teachers relied on their colleagues for support, and 3) state standards played a significant role in choosing and planning lessons. The findings of this study are applicable to anyone interested in pre-service and in-service science teachers, professional learning communities, and curriculum development.

What's In A Word? Teachers' Shifting Conceptualizations of "Authentic" Teaching and Learning in PBL

Tess Bernhard*, University of Pennsylvania, USA
Amy Guillotte, University of Pennsylvania, USA
Sarah Schneider Kavanagh, University of Pennsylvania, USA
Chris Pupik Dean, University of Pennsylvania, USA

ABSTRACT
Calls to transform school science often highlight the importance of more authentic instruction. Researchers argue that authenticity has multiple connotations; instruction can be authentic to real-world communities, students' experiences and interests, or the practices of disciplinary communities. In this study, we ask how science teachers understand authenticity in project-based learning (PBL) instruction. After an extended professional development (PD) program on authentic teaching practices in PBL, we find that teachers hold varied conceptions of authenticity. Following PD, teachers' conceptions both upheld their existing traditional school

science understandings of authenticity, while simultaneously expanding to take on new, reformed meanings. This raises questions about how to use language both flexibly and precisely to support teachers to develop complex and contextualized understandings of more transformative teaching practices.

Integrated STEM Design and Implementation: a Case with In-service Teachers

Argyris Nipyrakis*, University of Crete, Greece
Dimitris Stavrou, University of Crete, Greece
Lucy Avraamidou, University of Groningen, Netherlands

ABSTRACT
Although there is an increasing attention in integrated STEM in the literature, little is known on how this is been implemented by the agents of this innovation, i.e. the in-service teachers. Hence, the present study investigates the design and development of STEM teaching material from secondary in-service teachers (n=26) coming from all S-T-E-M disciplinary backgrounds, who participated in a STEM professional development program. In specific, teachers' designed STEM lesson plans are been analyzed based on the key characteristics of Roehrig et al.'s (2021) conceptual framework of integrated STEM. Results of the study reveal teachers' preferences as well as deficiencies in each key characteristic. Some divergence between teachers coming from 'natural' sciences (science, mathematics) and 'design' sciences (technology, engineering) was noted in relation to their approach to engineering design. Moreover, the 'STEM careers' dimension appeared limited in the developed lesson plans.

Exploring Teachers' Design and Enactment of Rigorous Lessons through a Collaborative Design Experience

Ryan Coker*, Florida State University, USA
Danielle Rhemer*, Florida State University, USA
Ozlem Akcil-Okan*, Florida State University, USA
Sierra Morandi*, Florida State University, USA
Jennifer Schellinger, Florida State University, USA
Miray Tekkumru-Kisa, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT
Reform efforts targeting science instruction emphasize that students should develop scientific proficiency that empowers them to collaboratively negotiate science ideas as they develop meaningful understandings about science phenomena through science practices. The lessons teachers design and enact play a critical role in engaging students in rigorous science learning. Collaborative design, in which teachers work together to design, enact, and reflect on their teaching, holds potential to support teachers' learning, but scarce research examines the pathways by which collaborative design can influence teachers' instructional practices. Examining the teaching and reflective thinking of two science teachers who engaged in collaborative design activities over two years, we found that their enactment practices became more supportive of students' rigorous learning over time, and that they perceived collaborative

efforts with teacher educators and partner teachers to plan lessons and analyze videos of instruction as supportive of their learning to enact rigorous instruction.

Strand 10: Curriculum and Assessment
Symposium: Reinventing Scientific Literacy for an Age of Misinformation: NGSS 2.0
4/20/23, 16:30-18:00, Salon A5 (LL)

Reinventing Scientific Literacy for an Age of Misinformation: NGSS 2.0

Jonathan Osborne*, Stanford University, USA
Douglas Allchin, University of Minnesota, USA
Noah Feinstein*, University of Wisconsin-Madison, USA
Ayelet Baram-Tsabari*, Technion University, Israel
Daniel PImentel, Stanford University, USA

ABSTRACT
On the 10th anniversary of NGSS the goal of this symposium is to initiate a discussion of how these standards can be improved. While we address a number of issues of concern in NGSS, the particular focus of this symposium is the rise in scientific misinformation in recent years and the need to develop competent outsiders to science. The NGSS were written for what seems a different era before the internet released a maelstrom of misinformation that is a threat to science and the rationality that is its core commitment. Rather the existing standards rest on an unfounded belief that it is possible to acquire sufficient knowledge to sustain intellectual independence. Such a perspective is unsustainable when confronted by the complex science of today's society that lies far beyond the boundaries of school science. In short, we are all epistemically dependent and the issue for science education is what it can do to reduce the epistemic distance between the scientific experts, on whom we all depend, and the lay person. Three of the contributors will present a theoretical rationale which will be supported by one empirical contribution showing what it is possible to do.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Critical Race Theory: Interrogating Resilience, Diversification, and the Model Minority Myth across STEM Education
4/20/23, 16:30-18:00, Salon A2 (LL)

Promoting [Policy] Reform Over Perseverance: Interrogating the Definition of Black Resilience in STEM Education

Takeshia Pierre*, University of Florida, USA
Felicia Mensah, Columbia University, USA

ABSTRACT
In recent years, literature devoted to applying resiliency-centered interventions for minoritized populations have been studied within the context of higher education. Naturally, science education and STEM disciplines have also incorporated resiliency within studies geared toward improving the educational experiences for students of color. With the underrepresentation of minoritized populations entering STEM fields, researchers have aimed to identify ways of increasing matriculation by means of targeting adults who occupy STEM and science education fields. Resiliency has been unearthed as a phenomenon used in exploration of strategies that influence successful STEM matriculation and/or persistence among minoritized populations – particularly Black undergraduate students. Understanding and solidifying a definition for resilience in STEM can aid in identifying key characteristics that improve academic achievement and assessing ways to focus on the barriers these underrepresented populations must be resilient from, rather than asking them to conform to these very barriers. The purpose of this paper is to identify how resilience has been defined in science education and STEM environments and interrogate whether these definitions should stand. We discuss how interrogation of these themes can serve as a tool to create an environment challenging conformity and further promoting the reformation of implicit and explicit science education standards.

Operationalizing Critical Race Theory to Diversify the Pre-Medical Undergraduate Path: A Theoretical Paper

Candice Kim*, Stanford University, USA

ABSTRACT
Prior work has demonstrated that the college premedical track disproportionately pushes out Black and Brown Undergraduates of Color from pursuing a career in medicine, particularly through prerequisite STEM courses. Previous interventions designed to diversify the premedical track have overwhelmingly targeted Black and Brown Undergraduates of Color, rather than the higher education system itself. These initiatives, however, have proven to be insufficient in adequately diversifying medicine. I argue that this has been the case because prior interventions have served to reify dominant ideology, rather than dismantle systemic oppression. In this theoretical paper, I operationalize Critical Race Theory (CRT) to argue for a different theoretical framing that centers the voices of marginalized students and actively works towards advancing social justice. I describe the key tenets of CRT and examine how these principles can inform future research and interventions using diversifying the premedical track as a case example. This paper offers a valuable introduction to CRT, its core tenets, and how this theory can be used as a conceptual framework to drive science teaching and learning in higher education.

"Would you comment on my English if I was White?": Asian American Women Experiencing STEM

Dionne Cross Francis*, University of North Carolina, USA
Pavneet Kaur Bharaj, University of North Carolina, USA
Jasmyne Yeldell*, University of North Carolina, USA
Kerrie Wilkins-Yel, University of Massachusettes, USA

ABSTRACT
As a basic right every individual should be able to pursue their desired professional goals However, for Women of Color choosing a STEM (science, technology, engineering and mathematics) career pathway, this choice seems to equate to a pathway of dehumanization, invisibility, and trauma (JeanMarie, 2011). How these marginalizing experiences unfold however are nuanced as Women of Color are not a monolith. These experiences are even more complex when we consider other identities, culture, and context, namely post-secondary environments, and immigrant identities. Recognizing the complex nature of STEM experiences of Women of Color, in this study we explored the nuanced experiences of three undergraduate and graduate Women of Color in STEM from immigrant, Asian backgrounds pursuing degrees at a predominantly white university in the South. We observed that they tended to minimize discriminatory experiences that were racialized and/or gendered and had both positive and negative interpretations of the racial stereotype referred to as the model minority myth. Despite how participants perceived it, the model minority myth seemed to rob the participants of their identity as hard working and diligent students. We discuss practical and methodological implications of our findings.

Understanding Systemic Racism in Science Teacher Educator Preparation
Felicia Mensah*, Teachers College, Columbia University, USA

ABSTRACT
This study focused on women of Color doctoral students in science teacher education contributes to our understanding of systemic racism as voiced by their educational experiences and preparation as teacher educators of Color. For this qualitative research study, a multi-layered approach was taken to examine systemic racism in science teacher education and the preparation of teacher educators of Color. The e-Journals from nine women of Color doctoral students were collected and analyzed for understanding systemic racism in teacher education. This purposive selection of participants was based upon several theoretical and methodological inclusion criteria to learn from their past and present experiences in teacher education and their understanding of systemic racism as women of Color in science education. Three conceptual themes are presented-- seeing racism: the Visibility of Racism as Endemic and Ingrained; defining racism: Systemic Racism in Education; and describing racism: Systemic Racism's Effect in the Science Classroom. The findings have implications for seeing systemic racism and its many manifestations in science teacher education. Once we know how it moves and acts, then we are in a better position to address it, through education and work toward more equitable policies and empowering practices in science teacher education.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Explorations of Social Justice and Anti-racist Science Teacher Identity
4/20/23, 16:30-18:00, Salon C1-2 (LL)

White shame and white ambivalence in learning to be a well-started White anti-racist science teacher

Jonathan McCausland*, New Mexico Highlands University, USA
Scott McDonald, Pennsylvania State University, USA

ABSTRACT
Science education has a white supremacy problem. As we continue to focus our attention towards creating an equitable science education, we need to start paying more direct attention to white supremacy (Le & Matias, 2019). Therefore, this study focuses on how white supremacy mattered in the learning of Boaz, a White man who participated in a secondary science program, as a part of a design-based research study. Using narrative methods, this case study shows how white shame (Thandeka, 1999) and white ambivalence (Ellison, 1953/1995) played a role in Boaz learning to be a well-started White anti-racist science teacher. This study contributes theoretically to understanding the role white supremacy plays in the learning of White interns and provides a new theoretical toolbox, critical whiteness studies, as a means to dissecting and dismantling white supremacy in science education. This study also provides practical implications for science teacher educators on how to support secondary science interns in grappling with white supremacy and learning anti-racist teaching practices.

Empowering Science Praxis: Lessons from a Social Justice Science Teacher Inquiry Group

Alexandra Schindel*, University at Buffalo-SUNY, USA
Sara Tolbert, University of Canterbury, New Zealand
Lauren Urban*, University at Buffalo-SUNY, USA
Kellyann Ramdath*, University at Buffalo-SUNY, USA

ABSTRACT
Student empowerment is an often cited but seldom described intended outcome of radical, justice-oriented, and critical schooling. In this paper, we delve into the meanings of one aspect of empowerment–academic empowerment–and how it was (re)conceptualized by a teacher inquiry group that met to examine the promises, complexities, and tensions involved in putting justice into practice in science education. Utilizing a participatory research design, the teacher inquiry group met for four years and with the following goals: a) engage in collective inquiry in teaching/learning science for social justice, b) use a framework for student empowerment to focus on how youth use and learn science within their personal and civic lives. Drawing upon Freire's (1971) conception of reading the word and the world, the inquiry group contended that academic empowerment occurs when students are taught (a) rigorous academic content and skills and are held to high standards and expectations and (b) to examine power inequities through critical analyses of the content being learned and relationships of power. We utilize this practice-centered analysis to explore what academic empowerment is, how tensions emerge in our practice, and how the inquiry group responded to them.

Enacting Social Justice Teaching Identities in Science Classrooms

Katherine Wade-Jaimes*, University of Nevada, USA
Rachel Askew, Freed-Hardeman University, USA

ABSTRACT
This proposal explores how teachers develop and enact social justice science teaching identities in science classrooms. As part of a larger study, interview and written reflection data was collected over one academic year from two teachers, both women early in their teaching careers. Analysis of the data showed that despite many structural obstacles, both women found ways to enact agency to support their identities as social justice science teachers. Ms. B. focused on supporting her students through authentic science learning experiences as a way to enhance their science identities as well as to integrate her identities as science teacher and social justice teacher. Ms. I. struggled with identifying as a "bad teacher" due to structures such as standardized testing, but ultimately regained her agency in order to better serve her students. By revising the "test prep" curriculum to be more exploratory, Ms. I. found a way to feel good about her science teaching identity and to push back against oppressive structures for herself and her students. These results highlight the ways in which social justice identities intersect with science teaching identities to support both teacher and student identity development as well as more authentic science learning experiences.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set: Applications of Technology for Data Analysis
4/20/23, 16:30-18:00, Blvd A (L2)

Technology as a tool for supporting indigenous youth's sense of consequential learning around earth science
Colby Tofel-Grehl*, Utah State University, USA

ABSTRACT
This paper reports findings surrounding Hawaiian youth's engagement with and around earth and physical science as they engage in land centered learning of the history and geology of their island. Findings indicate the Hawaiian youth feel greater connections and consequential learning (Hall and Jurow, 2015) within science when those funds of knowledge draw on their own histories, geographies, communities, and contexts. By engaging youth in learning in service to their community and needs, teachers are able to support and foster youth agency and advocacy for their own island community. Teaching coding and technology in service to these youth goals offered great adoption, integration and learning than science on its own. By designing for consequential learning and an integration of identity instead of a bifurcation of them, teachers and researchers can better support youth learning and interest in science.

Investigating Differential Effects of a Digital Ladder of Learning with Adaptive Support in Chemistry
Michelle Möhlenkamp*, University of Duisburg-Essen, Germany
Helena van Vorst, University of Duisburg-Essen, Germany
Sebastian Habig, University of Erlangen-Nuremberg, Germany
Mathias Ropohl, University of Duisburg-Essen, Germany

ABSTRACT
Heterogeneity in students' knowledge, cognitive abilities and interest is a significant characteristic of every school class. Teachers have to deal with this situation in every lesson and have to support students individually. In order to counteract this heterogeneity, the approach Ladder of Learning (LL) is appropriate to enable individual learning processes. In this project an existing example of a LL has been transferred into a digital version including adaptive support, and its effectiveness is investigated. In this way, the advantages of digital media can be used for learning. The digital Ladder of Learning (dLL) focuses on the topic Bohr's atomic model and was implemented in grade-nine chemistry classes. To investigate the advantages of the dLL, the students were divided into two groups: the intervention group worked with the new designed digital material with integrated adaptive support presented on tablets. The control group had comparable analogue material with the possibility to get separate adaptive support at its disposal. The intention of the pre-post quasi-experimental intervention study is to find out which effects a dLL has on students' knowledge and interest compared to a usual version.

Data-Driven Personas for Community Science in Paleontology
Richard Bex*, University of Florida, USA
Kent Crippen, University of Florida, USA

ABSTRACT
Anyone can participate in citizen and community science projects. Such projects have led to many positive scientific and educational outcomes. Unfortunately, the demographics of citizen and community science projects have typically been skewed toward older individuals. Many, particularly in paleontology, see the limited engagement from younger generations as an issue. One potential way to increase the level of participation in paleontology from younger generations is by creating an online space for those individuals to find information about the science of paleontology. In order to successfully develop and support platforms for citizen and community science in paleontology, it is important that project managers and developers understand the target end users. With user-centered design and communities of practice as a conceptual framework, this explanatory sequential mixed-methods study develops user personas—evidence-based narrative descriptions of key characteristics—to provide detailed descriptions of participants within one online space for community science in paleontology. The five user personas developed in this study could support the future design and development of other online communities for paleontology. Additionally, the personas identified in this study could aid in developing online communities of practice for community science and online community science spaces and mobile apps more broadly.

Designing and Developing an Instrument to Assess Scale Cognition
Tyler 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

ABSTRACT

Research has shown the inaccurate conceptions students hold regarding entities at various scales. We designed Scale Worlds, a virtual scale cognition experience with entities from the US science education standards ranging from 10-10 m (water molecule) to 109 m (Sun) in immersive virtual environments, to address these concerns. However, a review of the extant literature revealed that there were no suitable instruments for assessing scale cognition in our intended measurement medium, online platform, or otherwise sub-optimal, including time-intensive tasks and limitations in scope. This paper describes the development of a novel instrument, the Assessment of Size and Scale Cognition (ASSC), a computer-based assessment aligned with the framework to characterize and scaffold size and scale cognition (FS2C). Task items were designed for each conceptual dimension of the framework, guided by already existing instruments and then reviewed by a panel of experts. The expert panel's recommendations led to important changes of various types, dealing with the actual science content, the inclusion of student support, and the recommendation of novel approaches. The development of instruments, such as the ASSC, are essential in assessing the impact of instructional tools on student learning.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Symposium: Scientific Inquiry Literacy - Vision 1.5: A new focus for achieving scientific literacy
4/20/23, 16:30-18:00, Astoria (L3)

Scientific Inquiry Literacy - Vision 1.5: A new focus for achieving scientific literacy

Renee Schwartz*, Georgia State University, USA
Judith Lederman*, Illinois Institute of Technology, USA
Valarie Akerson*, Indiana University, USA
Selina Bartels, Valparaiso University, USA
Patrick Enderle*, Georgia State University, USA
Irene Neumann, IPN -Leibniz Institute for Science and Mathematics Education, Kiel, Germany
Kerstin Kremer, Justus-Liebig-University Giessen, Germany
Frauke Voilte, Leibniz Universität Hannover, Germany

ABSTRACT

Introducing Vision 1.5: Scientific Inquiry Literacy. Reflecting on decades of science education reforms, this symposium revisits the meaning of Scientific Literacy, from Bybees' (1995) dimensions, Roberts' (2007) Vision 1 (Science Literacy) and Vision II (Scientific Literacy), and their collective take as of 2014 (Roberts & Bybee, 2014). Reforms focused heavily on scientific inquiry for achieving scientific literacy, globally. Yet, there remain notable deficiencies in how learners understand what science is and what scientists do in constructing scientific knowledge. We only need to look at societies' responses to the global pandemic and climate change to see that mistrust and misunderstanding of science and scientists is a crisis. The panelists will discuss current research and trends related to the achievement of scientific literacy with respect to inquiry-based recommendations. We introduce the construct of

Scientific Inquiry Literacyas essential to cognitively transition from being Science Literate to being Scientifically Literate. This session shines light on the state of Scientific Inquiry Literacy across grade levels and internationally. Recommendations are offered for research, curriculum, and assessments in efforts to understand of the role of scientific inquiry literacy for scientific literacy in a world with global socio-scientific issues, science mistrust, and science misunderstanding.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set: Socio-scientific issues and Culturally Responsive Environmental Science Education
4/20/23, 16:30-18:00, Blvd C (L2)

Incorporating community and citizen science into schools: How children develop science identity in California forests

Jadda Miller*, University of California Davis, USA
Shulong Yan*, University of California Davis, USA
Heidi Ballard, University of California Davis, USA

ABSTRACT
As community and citizen science (CCS) projects around the world have started to engage schools in studying environmental threats and impacts on planetary health, there is enormous potential for CCS to transform science learning, particularly in elementary schools. Yet, little empirical research on science learning outcomes of citizen science exists for this age group. Researchers and educators assume that youth participation in scientific research and monitoring, which we call youth-focused community and citizen science (YCCS), will support engagement in scientific reasoning practices in schools. However, there is much variation within YCCS program design and therefore learning outcomes from engagement in educational settings. YCCS is touted as a possible means to foster youth agency and identity with science but a dearth of research exists on this particular topic in school settings and in related informal science learning contexts. As more teachers and schools adopt YCCS programs for youth learning, there is an increasing need to understand what is required of YCCS project design in schools and raises the question of how best to incorporate authentic, community-relevant scientific research into the fabric of formal school systems and whether or not these programs yield impactful science learning while contributing to local environmental problem-solving.

Exploring Elementary Students' Socio-scientific Argumentation within an Ecosystem Related SSI-based Unit

Nannan Fan*, University of North Carolina at Chapel Hill, USA
Li Ke, University of Nevada at Reno, USA
Jamie Elsner, university of north Carolina at Chapel Hill, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA
Laura Zangori, University of Missouri., USA

ABSTRACT
One of the overarching goals in science education is to prepare students to negotiate and resolve science-related everyday issues. Engaging students with argumentation practice in the contexts of socio-scientific issues (SSI) has been proven effective to address this goal. While prior studies have mainly explored students' SSI argumentation at the secondary level, few focus on primary students. In this study, we address the gap and explore third graders' SSI argumentation within an ecosystem related SSI-based unit. We used the mixed methods to study students' SSI writings at three time points. To assess students' SSI argumentation, we created a rubric from the argumentation and SSI literature as well as our initial data exploration. We used an iterative process to examine how well the rubric captured primary students' SSI writing. The results show that with curricula support, primary students are able to develop sophisticated argumentation practice about complex issues. The findings also indicate that primary students' SSI argumentation development is complex. There seemed to be interactions between sub-dimensions (e.g., science ideas vs.value) that are worth further research. Moreover, the scoring rubric has potential for better capturing students' SSI argumentation practice, especially for young children, that feature both disciplinary norms and personal factors.

"Get kids outside!": Integrating Culturally Responsive Teaching with NGSS-aligned Environmental Science

Marisa Ritchie*, California Polytechnic State University, USA
Spencer Paine*, California Polytechnic State University, USA
Sierra Martin*, California Polytechnic State University, USA
Jasmine Nation, California Polytechnic State University, USA
Kurt Holland, California Polytechnic State University, USA

ABSTRACT
Researchers have clearly outlined the benefits and best practices of outdoor learning and are making strides toward culturally responsive environmental education, but have less insight into supporting classroom teachers in bringing their students outdoors themselves. Therefore, we investigated a week-long professional development providing standards-based tools and strategies surrounding culturally responsive environmental science. We applied a design-based research approach to analyze PD artifacts and surveys from 33 upper elementary teacher participants. We present three themes arising from teachers' shifting perspectives on NGSS-aligned science (ease of integration, true 3 dimensionality, and outdoors as a classroom) and how their views on culturally responsive teaching and environmental education changed across the PD. For example, we documented how teachers were empowered by viewing the outdoors as a classroom, and began to focus on the hyper local–getting students to explore their own schoolyards, including students in the action planning process, and doing multi-subject lessons outdoors. We hope drawing on program processes and design decisions can help encourage more teachers to simply "get kids outside" in ways that are academically rigorous and inclusive.

Environmental Health Investigators: developing science interest with a diverse group of middle school students

Andreia Dexheimer*, Southern Illinois University Edwardsville, USA
Sharon Locke, Southern Illinois University Edwardsville, USA
Georgia Bracey, Southern Illinois University Edwardsville, USA
Ben Greenfield, University of Southern Maine, USA
Jennifer Zuercher, Southern Illinois University Edwardsville, USA
Carol Colaninno, Southern Illinois University Edwardsville, USA
Candice Johnson, Southern Illinois University Edwardsville, USA
Charlie Blake, Southern Illinois University Edwardsville, USA

ABSTRACT
We designed and developed a program to investigate STEM interest development in underserved middle school students. We combined high-impact educational practices and applied environmental education methodologies, using student choice and community relevance as central tenets for curriculum design and programming. Our conceptual framework was based on Hidi and Renninger's 2006 model of interest development which consists of four phases: triggered situational interest, maintained situational interest, emerging individual interest, and well-developed individual interest. We used a mixed methods approach to answer the question: to what extent does participation in program activities increase interest in STEM-related career fields? We found an increase in STEM-related career interest in both our qualitative and quantitative data. Interviews indicate a move from situational interest to individual interest which might lead to well-developed interest if students continue to engage in STEM-related activities. Surveys showed a significant increase in STEM-related career interest (paired t-test: $t = -3.752$, p-value $=0.00174$). Triggering situational interest can play a role in career interest, leading to re-engagement and well-developed individual interest. We expect the paper will be of interest to NARST members working on environmental or informal education with youth in underserved areas and researchers interested in science interest development theory.

Equity And Ethics Committee
Social Event: Equity and Ethics Dinner
Grant Park Bistro
4/20/23, 18:10-21:00

Equity and Ethics Dinner: Grant Park Bistro

ABSTRACT
You must register for this event with your Advance Conference Registration. Tickets purchased for this event are not refundable.

Board of Directors
Membership and Business Meeting
4/21/23, 8:00-8:50, Salon A1 (LL)

Concurrent Session 11
4/21/23, 9:00-10:30

Southern African Association for Research in Mathematics, Science and Technology Education (SAARMSTE)
Sponsored Session: Twenty years of growth in science education capacity in Southern Africa - SAARMSTE Research School
4/21/23, 9:00-10:30, Salon C5-6 (LL)

Twenty years of growth in science education capacity in Southern Africa - SAARMSTE Research School

ORGANIZERS
Marissa Rollnick, Wits University, South Africa

PANELISTS
Elizabeth Mavhunga, Wits University, South Africa
Peter Hewson, University of Wisconsin, USA
Julie Luft, University of Georgia, USA
Ryan Nixon, Brigham Young University, USA
Regina McCurdy, Georgia Southern University, USA

ABSTRACT
The SAARMSTE (Southern African Association for Research in Mathematics, Science and Technology Education) Research School has, over 20 years, grown in its geographical footprint in serving the wider African continent with participation from the global science education community. Nearly 500 doctoral students from institutions in 15 countries have been assisted by more than 50 facilitators, from institutions in 6 countries. Many have attended multiple Research Schools. The Research School is organized around research stages - Proposal Writing, Theoretical Frameworks, Data Collection & Analysis, and Writing for Publication. An expanding emphasis is assistance to emerging researchers and apprentice facilitators. Participants are grouped in these stages, based on their own thesis topics. In these groups, participants make progress on their topics through presentations, workshops, group discussions, one-on-one reviews with facilitators who provide feedback of work accomplished to date, and informal conversations with other participants. NARST has supported SAARMSTE"s Research Schools through 2 LSEP grants, 2 NARST doctoral students every second year, and, this year, signing an MOU with SAARMSTE. Speakers at the symposium will

reflect on the influence of the research school on the participants" doctoral education from multiple perspectives - that of founder facilitator, international and local facilitators, student then facilitator, and international and local doctoral students.

Strand 1: Science Learning: Development of student understanding
Related Paper Set: It's never too early: Insights from empirical studies concerning evolution in kindergarten and elementary school
4/21/23, 9:00-10:30, Salon A1 (LL)

Young Children's Understandings of Camouflage as an Adaptation

Lisa Borgerding*, Kent State University, USA

ABSTRACT

Previous research has concluded that preschool and early elementary children can learn about natural selection and offer selection-based explanations for generational change. Young children are better able to offer selection-based reasoning for behavioral traits such as foraging compared to external traits such as camouflage, and researchers have reasoned that camouflage requires background knowledge prior to selection-based reasoning. This study explores children's ideas about camouflage throughout a week-long STEM camp that explicitly examines camouflage as an adaptive trait. Specifically, this study investigates how children understand coloration as a trait that varies, is heritable, and impacts survival and reproduction. The sample consisted of 29 children aged three through nine enrolled in three age-grouped classes. Data collection entailed a pre/post test examing environmental matching, variation, inheritance, and differential survival/reproduction for a camouflaged animal as well as daily work that prompted students' ideas about these concepts. Results indicate that even young children have some understanding of camouflage as a heritable trait that confers selective advantages and that older children at age four and above consistently recognize the existence of coloration trait variation and inheritance. Implications for curriculum development and early childhood education are provided.

Elementary-school students' can develop understanding of evolution by natural selection based on a storybook-based curriculum

Deborah Kelemen*, Boston University, USA
Sarah Brown, Boston University, USA
Alden Burnham, Boston University, USA
Gillian Puttick, TERC, USA
Sally Crissman, TERC, USA
Sara Lacy, TERC, USA
Jessica Findlay, University of Surrey, United Kingdom
Aarti Bodas, Boston University, USA

ABSTRACT
Natural selection (NS) is a fundamental mechanism of evolution, the unifying principle of biology. Despite its centrality to science, research indicates that older students often misunderstand it. A source of these misunderstandings are intuitive explanatory tendencies that emerge in early childhood, but that typically remain largely unchallenged until middle or high school–long after these preconceptions have become entrenched. This Design Based Research responds to this challenge by exploring the benefits to elementary-school students of an innovative storybook-based 3D elementary school curriculum on the mechanisms of small-scale (e.g. adaptation) and large-scale (e.g. speciation, common ancestry) evolution by natural selection. Pre-to-post test results from Year 2 of this project with 177 third graders in 11 classrooms (3 school districts) found that approximately 95% of students entered with little or no understanding of NS. However, after engaging in the 10-lesson unit, approximately 60% had constructed an accurate population-based understanding of evolutionary change based on differential survival and reproduction. About 75% students had scientifically inaccurate preconceptions at pre-test but only 20% displayed them at post-test. These findings help to fill a substantial empirical knowledge gap by yielding preliminary evidence of a beneficial 3D NGSS curriculum on evolution by natural selection from elementary school.

Learning evolution at home: Virtual intervention for elementary school students and their parents

David Menendez*, University of Michigan, USA

ABSTRACT
Evolution is a unifying principle in biology and one of the key concepts in biology education. However, people across ages and education levels often struggle to understand evolution. Research on informal learning suggest that parent and children discuss evolution, but have not assess whether children learn from these informal interactions about evolution. To examine this, we recruited 83 child-caregiver dyads to complete a two-session online study about how people learn about evolution. In the first session, parents and children completed a pretest to assess their understanding of evolution. In the second session, they read an e-book about evolution through natural selection, and completed a posttest to assess their learning and generalization. They were assigned to read an e-book about with either colorful drawings or black-and-white drawings. Results show that elementary school children are able to learn about evolution through an informal shared book reading activity, regardless of whether the book as colorful or not. Additionally, children were able to transfer this knowledge to related scenarios. This study shows that when given appropriate materials, children can learn about evolution at home, long before this concept is formally introduced in school.

Dialogues about evolution: Interviewing young children to assess their ideas about evolutionary concepts

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
Researchers argue that the integration of evolution in early education might facilitate later learning in school. Thus, a growing body of interventions aim at promoting children's knowledge about aspects of evolution. However, (1) there are no consistent procedures for evaluating interventions' effects on children's learning, and (2) children's ideas about plant evolution are hardly considered. In this study, we aim to develop and evaluate an interview to measure knowledge of kindergarten children about the evolutionary principles covering plants and animals. It includes 29 closed and open-ended questions addressing nine key concepts that are connected to variation, inheritance, or selection. We piloted the interview in three rounds and conducted the main data collection with 24 children aged five to six years. The children mostly gave appropriate answers and rarely asked clarification questions. Even though we expected children to express lower levels of mental models when asked about plants, this was not true for all key concepts. For example, the children expressed more advanced ideas about animal compared to plant reproduction, but often scored equally high on items about individual variation. Our study provides new insights into how knowledge about evolution can be measured even at a young age.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Communicating Science Through Visuals and Connections
4/21/23, 9:00-10:30, Salon A2 (LL)

Impact of Choice in Lab Exercises on Students of Different Grade, Ability, and Sociocultural Background

Laura Sührig*, Goethe University Frankfurt, Germany
Katja Hartig, Goethe University Frankfurt, Germany
Albert Teichrew, Goethe University Frankfurt, Germany
Roger Erb, Goethe University Frankfurt, Germany
Jan Winkelmann, University of Education Schwäbisch Gmünd, Germany
Mark Ullrich, Goethe University Frankfurt, Germany
Holger Horz, Goethe University Frankfurt, Germany

ABSTRACT
Lab exercises are an essential component of science education and for many teachers a central element of physics lessons. To make lab exercises more inclusive we must design them in a way that meets the requirements of students with different strengths, weaknesses, interests, experiences and backgrounds. A framework that helps with this task is the Universal Design for Learning (UDL). UDL calls for multiple means of representation which the students can choose from. Our proposal for an inclusive lab exercise based on UDL is to combine five different modes of experimentation and give the students the opportunity to choose from them. In our study we aim to find out what impact this freedom of choice in a lab exercise has on certain variables in a classroom setting. Therefore, we compare two different lab exercises with each other: one where the students choose two out of the five experiments (intervention group) and one where the students were given two experiments. In the intervention study (nmatched =

373) we found out that choice made a statistically significant positive impact on learners' intrinsic motivation and perceived choice. However, the group with no choice had a more positive development of their self-concept.

A State-of-Affairs Review of Science-specific Disciplinary Literacies

Molly Marek*, University of Texas, USA
Misty Sailors, Colorado State University Pueblo, USA
Chris Ham, University of North Texas, USA
Mariyeni Matariro, University of the Witwatersrand, South Africa
Alana Newell, Baylor College of Medicine: Center for Educational Outreach, USA

ABSTRACT
The early 2000's brought substantial shifts in the ways literacy experts thought about literacy in the content areas. Since this time period, a comprehensive review has not been published. The purpose of this study is to provide a "state-of-affairs" review of the field of science-specific disciplinary literacy. This aggregative synthesis addresses how disciplinary literacy is framed, defined, studied, and discussed and illustrates trends in the literature including theoretical frameworks used, authorship of studies, and study contexts. Future directions for the field are outlined. We hope to generate a conversation that propels the field of science-specific disciplinary literacy forward.

A historical analysis of the standards for graph construction in the US

Cesar Delgado*, North Carolina State University, USA
Alonzo Alexander, North Carolina State University, USA

ABSTRACT
Graphs are some of the most basic and important visual displays in science. However, there is currently no authoritative source of principles for graph construction. This paper abstracts conventions for graph construction from US national standards documents from 1915 to the withdrawal of the last standard in 1994, using document analysis and grounded theory. The currency of the conventions is tested by analyzing default Excel graphs. Eighteen conventions were generated, and organized into five classes: Spatial Characteristics; Data Point Characteristics; Scale Characteristics; Multiple Scale Considerations; and Label Characteristics. Default scatterplot graphs in Excel were analyzed for conformance to the 18 conventions. This study generates a grammar and syntax for graphs, providing a foundation for more effective communication.

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

SC-Organized Paper Set: Designing, Supporting, and Enacting Elementary Science Units for Teacher Phenomenon Adaptation

4/21/23, 9:00-10:30, Blvd A (L2)

A Theoretical Model for Pedagogical Design Capacity for Phenomenon Adaptation

Katahdin Cook Whitt*, Maine Mathematics and Science Alliance, USA
Lisa Kenyon, Maine Mathematics and Science Alliance, USA
Emily Harris, BSCS Science Learning, USA

ABSTRACT
Teaching is a complex and multifaceted design activity, which requires teachers to draw on their personal teaching resources in addition to instructional resources in order to craft instructional episodes and make productive adaptations to curriculum materials. Pedagogical Design Capacity (PDC) refers to a teacher's ability to draw on their personal teacher resources and instructional resources as they make productive changes to curriculum materials. In this paper, we present a theoretical framework that draws on and extends the concept of PDC to focus specifically for phenomenon adaptation. In our extended theoretical framework for PDC for phenomenon adaptation, we add place and community resources to the existing teacher and instructional resources from which teachers draw on when making design decisions. Further, we elevate specific types of instructional resources and teachers resources that are specific to places and communities.

Designing Storyline Units for Phenomenon Adaptation

Emily Harris*, BSCS Science Learning, USA
Lindsey Mohan, BSCS Science Learning, USA
Candice Guy-Gaytán, BSCS Science Learning, USA
Katahdin Cook Whitt, Maine Mathematics and Science Alliance, USA
Lisa Kenyon, Maine Mathematics and Science Alliance, USA
Darryl Reano, Arizona State University, USA
Cindy Soule, Portland Public Schools, USA

ABSTRACT
Phenomena in storyline units are often designed for high interest of broad audiences, yet are not necessarily customized so students investigate phenomena relevant to their own lives, cultural worlds, and communities. To explore opportunities for teachers to adapt units so locally or culturally relevant phenomena drive instruction, we draw on a model-based storyline approach and layer on emergent place-based approaches to explore: how can designers create storyline units that invite phenomenon adaptation by teachers? We present a nascent design framework for an elementary science unit designed for phenomenon adaptation in which teachers could add or replace phenomena in a designed unit. We identified one key modification to a storyline design process to design for phenomenon adaptation: categorizing candidate anchor phenomena prior to selection. We also made three additional modifications to the architecture of the unit design including: using a suite of anchoring phenomenon cases instead of one anchor, designing some investigative phenomena to be adapted, but not all, and integrating supports for related phenomena integrated throughout the unit. Findings from our design work offer insights for how to build upon and modify storyline design processes and products to create units that invite phenomenon adaptation by teachers.

Supporting Teachers Pedagogical Design Capacity to Make Phenomena Adaptations

Lisa Kenyon*, Maine Mathematics and Science Alliance, USA
Katahdin Cook Whitt, Maine Mathematics and Science Alliance, USA
Adrienne Hanson, Maine Mathematics and Science Alliance, USA
Emily Harris, BSCS Science Learning, USA
F. Leonard Kenyon, Maine Mathematics and Science Alliance, USA
Rhonda Tate, Maine Mathematics and Science Alliance, USA

ABSTRACT
Through professional learning that supports the development of teachers' pedagogical design capacity (PDC), teachers can be positioned and empowered to make adaptations to instructional materials to engage their students interest and identities (Brown, 2002; Knight-Bardsley & McNeill, 2016). In this paper, we examine the question: In what ways do teacher resources develop over time while participating in a professional learning experience and implementing a designed unit focused on scientific sensemaking and phenomena adaptations? Our design goal for a virtual professional learning experience was to provide teachers ongoing support in a peer group to enable phenomena adaptations to designed instructional materials. We found that teacher's PDC for sensemaking and phenomenon adaptation developed through their experiences. Teachers made shifts from traditional ways of teaching science that students "learning about" and moved toward science teaching where students are "figuring out" science ideas by building knowledge over time. Teachers who had more expertise with scientific sensemaking from the beginning of the unit, felt more confident in making adaptations, connecting the science unit to the local community and student interest. Teachers, new to sensemaking ideas indicated slight confidence with making adaptations, and yet still made progress with adapting.

Teachers' Design and Enactment of Phenomena Adaptations

Adrienne Hanson*, Maine Mathematics and Science Alliance, USA
Lisa Kenyon, Maine Mathematics and Science Alliance, USA
Katahdin Cook Whitt, Maine Mathematics and Science Alliance, USA
Emily Harris, BSCS Science Learning, USA
Seth Van Doren, BSCS Science Learning, USA

ABSTRACT
K-12 science teachers value instructional material that are both aligned to state standards and culturally relevant. While most teachers report that their instructional materials adequately support student mastery of state science standards, fewer teachers report that their instructional materials are adequately culturally relevant and reflect students' diverse identities. Phenomena adaptation empowers teachers with the opportunity to build on and grow the identities and interests of their students while implementing curriculum designed for the NGSS. This study investigates teacher designed and enacted phenomena adaptations during initial implementation of a 6-8 week earth science unit designed for NGSS and local adaptation. Data collection occurred in six, 4th grade classrooms from rural, urban, and suburban communities in the West, Northeast, and Southwest regions of the United States. Teachers attended twelve weekly, 1-1.5 hour professional learning sessions and responded to eleven video journal

prompts as they implemented the unit with students. A classification system for phenomena adaptations was developed from the project's design intentions and from preliminary data analysis of teacher designed phenomena adaptations. Classifications include: phenomena type, strategy, curriculum use, and origin. Examples from all but one category within our classification system were observed and reported.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Achievement Gaps and Cultural Considerations in STEM Instruction
4/21/23, 9:00-10:30, Salon C1-2 (LL)

Addressing Asymmetries in General Chemistry through an Asset-Based Approach

Hannah Sevian*, University of Massachusetts Boston, USA
Klaudja Caushi, University of Massachusetts Boston, USA
Jessica Karch, Tufts University, USA
Tamari Kakhoidze, University of Massachusetts Boston, USA
Vishakha Agarwal, University of Massachusetts Boston, USA
Tyson King-Meadows, University of Massachusetts Boston, USA

ABSTRACT
First-semester General Chemistry (GC1) functions as a gatekeeper to STEM degrees, asymmetrically impacting students who are non-white, from lower socioeconomic groups, non-native English speakers, two-year college transfers, and first-generation. At a highly diverse university, serving students primarily from these populations, up to half of GC1 students earn grades of D, F, or withdraw (termed DFW), contributing to STEM degree attrition. Many studies have focused on differences between DFW and ABC outcomes to illuminate mitigation strategies. However, extensive evidence demonstrates that deficit remediation strategies do not sustain benefits. Asset-based approaches, uncommon in higher education, offer an alternative. With a cultural wealth-oriented approach and design-based iterations on building a 1-credit asset-based supplemental course for DFW-risk students currently enrolled in GC1, we study students' experiences in chemistry and across university support structures, and the subsequent progress of GC1 students. The intervention results in closing some gaps but depends on the assessment emphases in GC1. Elements of the supplemental course design that are most supportive of student success include panels of advanced peers, nurturing attitudes of instructors, and multimodal strategies for problem solving. Amplification occurs with recognition and valuing of students' assets by GC1 instructors, faculty and professional advisors, and care counselors.

Narrowing achievement gaps in reformed general chemistry courses with and without in-class active learning

Ted Clark*, The Ohio State University, USA

ABSTRACT
Underrepresentation of some populations in STEM fields occurs because these students experience achievement gaps with performance lower on average then their overrepresented peers. Interventions to reduce achievement gaps and increase the retention of underrepresented students in STEM courses include approaches found both inside and outside of class-time, with active learning being a leading example of an in-class intervention in which didactic instruction is replaced by interactive or student-centered activities. In this investigation, student performance was examined in two reformed general chemistry courses that employed in-class active learning strategies when taught in person, but largely reverted to didactic instruction when the courses were taught online by the same instructors during emergency remote teaching. In both settings, achievement gaps for underrepresented minority students were significantly narrowed compared to students in classes with traditional instruction, suggesting that course elements beyond active learning in reformed courses are significant contributors to student success.

Using Cultural Historical Activity Theory to Characterize Different Enactments of the LA Model

Jessica Karch*, Tufts University, USA
Sedrah Mashhour, Tufts University, USA
Ira Caspari-Gnann, Tufts University, USA

ABSTRACT
Characterizing different enactments of instructional reform approaches is key to improving science education. The Learning Assistant (LA) model leads to many positive student outcomes in a wide range of STEM courses. However, discrepancies in outcomes in different introductory STEM courses have led to a call for more work investigating how the LA model is implemented. This multiple-case study seeks to bridge that gap by providing a high-resolution comparison of three LA-facilitated physics and chemistry courses at two institutions. We used cultural historical activity theory (CHAT) to characterize the activity systems of LA-facilitated interactions and the whole class discussion immediately following these interactions, to understand how instructors leveraged these interactions in their instruction and the roles LAs played in that integration. We found that integrating small group interactions lies on a spectrum based on the extent to which the instructors used student ideas (developed during small group discussion) as mediating artifacts in the whole class discussion, enabled by different divisions of labor and driven by instructors' different goals. Furthermore, we found that LAs provided both conceptual and emotional support to students to support the integration. Implications for teaching with LAs, and for research on instructional reform more broadly will be discussed.

Strand 6: Science Learning in Informal Contexts
SC-Organized Paper Set: Understanding Participation in Citizen Science and Science Communication
4/21/23, 9:00-10:30, PDR 2 (L3)

Concurrent Session 11, 4/21/23, 9:00-10:30

The relevance of science education to science-informed behavior: The case of COVID-19 in Israel

Ayelet Baram-Tsabari*, Technion - Israel Institute of Technology, Israel
Yael Rozenblum, Technion - Israel Institute of Technology, Israel

ABSTRACT
In recent decades, science education has become mandatory in many countries, under the assumption that it has value for everyday life, by supporting better, more logical, and informed science-related decisions. Paradoxically, the conjecture that science education helps people make evidence-based decisions, itself lacks direct evidence. Here, we tested for a possible correlation between the level of science education or scientific knowledge and science-based decision making in the context of real-life COVID-19 dilemmas. We show that the level of formal science instruction received did not significantly explain any of the variances in participants' adherence to social distancing guidelines, the use of health-related justifications for doing so, or identifying credible sources of information. General science knowledge and science knowledge in the context of COVID-19 played a role in predicting adherence to social distancing guidelines, but this relationship disappeared when other values, such as supporting one's sports team, dominated. This study provides unique empirical evidence regarding the long-term transferability of science education to the personal lives of non-scientists, and our results support the need to develop approaches to enhance the coherence between the stated goals of science education, and its actual effects on behavior.

Wild Boars and Humans in Haifa: Media Framing of Socio-scientific Issues

Tali Tal*, Technion, Israel Institute of Technology, Israel
Avshalom Ginosar, The Max Stern Yezreel Valley College, Israel

ABSTRACT
We studied a real socio-scientific problem: Invasion of wild boars into a city in Israel, and how it is communicated to the public by the local and national media. The context allows participation in public discourse over management, nature-conservation, wellbeing, etc. But the question is whether and to what extent does the media coverage take this opportunity? Limited scientific literacy of the public, and decision makers highlight the need to study how the issue is communicated and discussed in the public arena and the extent to which it reflects the complexity of socio-scientific issues. We analyzed 209 items published in local and national online and print media in 2019-2021, and found that the wild-boars issue became central in the public-discourse because of its relevance to residents and because of its ecological consequences. This is evident in 50% of the items dealing with the phenomenon only indirectly, and address it in a variety of other contexts. The local media dealt with solutions, policy decisions, values and conflicts no less, and even more than the national media. Almost 50% of all items dealt with broad aspects of the socio-scientific issue. In most items, features of socio-scientific issues were outstanding.

Concurrent Session 11, 4/21/23, 9:00-10:30

Mapping the Training Ground: LCA of Graduate Student Perceptions of Scicomm

Brenda Guerrero*, FIU, USA
Remy Dou, FIU, USA
Melissa McCartney, FIU, USA

ABSTRACT

Science communication, or scicomm, is increasingly recognized as a critical component to scientific research; yet, it is difficult for scientists to obtain the skills and training necessary to effectively communicate their science with broader audiences. Accessibility to training and opportunities to communicate science is even more complicated for graduate students still in the process of learning to navigate academia. Understanding graduate students' perceptions as it relates to scicomm is critical in preparing the future generation of scientists to effectively communicate science with the public. Their experiences, however, are critically underexplored in the current research literature. This study expands on a recent survey of graduate students across the US and abroad, gathering data on their scicomm experiences. In further analyzing these data, we were able to (1) identify profiles of graduate students based on how they define science communication and (2) compare how these definitions relate to their participation in scicomm. The findings from this study reinforce the need to understand graduate student scicomm perceptions to provide them with better opportunities to effectively engage the public.

Knowledge, curiosity, and relevance: Using the Elaboration Likelihood Model to help identify COVID-19 misinformation

Yael Rozenblum*, Technion – Israel Institute of Technology, Israel
Keren Dalyot, Technion – Israel Institute of Technology, Israel

ABSTRACT

Misinformation uptake has consequences for the public's behavior and decision-making. The Elaboration Likelihood Model (ELM) refers to the cognitive effort individual expends to evaluate information and it is dependent on one's abilities and motivation. Abilities are determined by the individual's prior knowledge and motivation is determined by curiosity relevance. Here we use the ELM to empirically explore if abilities (science knowledge and knowledge in the context of COVID-19) and motivation (exposure to COVID-19 and curiosity about science) can help to identify misinformation in the context of the COVID-19 pandemic. An online questionnaire was distributed among a representative sample of 500 Hebrew speakers in Israel after the second lockdown (Nov.9-18,2020). The questionnaire included close-ended and open-ended questions that measured: (1) general science knowledge (2) knowledge in the context of COVID-19 (3) curiosity about science (4) exposure to COVID-19 (5) identification of misinformation in which respondents were asked to report strategies they used to identify misinformation. Respondents with higher levels of general science knowledge, curiosity, and exposure to COVID-19 are expends more cognitive effort in the identification process. This empirical evidence underscores the role of abilities (science knowledge) and motivations (curiosity and relevance) in supporting students' ability to identify misinformation.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Using Virtual Platforms and Online Experiences in preparing future science teachers
4/21/23, 9:00-10:30, Salon C3-4 (LL)

Using Virtual Platforms as Out of School Environment: Examine the shift in student teachers' perspectives

Tugba Yuksel*, Recep Tayyip Erdogan University, Turkey

ABSTRACT
Virtual platforms such as virtual reality, artificial reality and virtual museums are one of these cutting-edge, rapidly evolving technologies. Recent research has shown that virtual environments are an effective and straightforward approach to teach science to students of all ages. They provide an environment for activities that can be carried out anywhere without the need for any material other than mobile devices, allowing students to acquire the notion of science. The aim of this study is to examine the views of student teachers' views about integrating virtual platforms into science teaching before and after developing a virtual out-of-school learning lesson plan and implementing it in a middle school science lesson. The results of this study suggest that although student teachers believe that using virtual out-of-school learning activities to teach science is innovative and beneficial, only a few STs were considering using virtual platforms since they believe it is time-consuming and it is more difficult to find a VOOSL activity than real OOSL activities. When they implemented their virtual lesson plans with middle school students, they changed their views on using virtual platforms in science lessons.

Virtual Elementary Science Teacher Preparation: Exploring Summer Science Institute Design Structures and Outcomes

Stephen Thompson*, University of South Carolina, USA

ABSTRACT
To respond to issues associated with rural science teacher preparation our research group created a virtual science summer institute that engaged teacher residents, coaching teachers, and supervisors in shared learning and teaching experiences with elementary students. This study focused on how participation in the institute model impacted rural elementary 1) teacher residents' perceptions of their content and pedagogical knowledge, and 2) coaches' (teachers and supervisors) perceptions of their coaching abilities and preparedness. The research team used a mixed methods study design. Data collection included field notes, interviews/focus groups, and surveys. Data from field notes, interviews, and focus groups were coded using an open and axial coding process. Teacher residents reported particularly high content outcomes gains in STEM and Computer Science. Participation also increased the residents' perceptions of their pedagogical knowledge. Teacher residents further shared that the virtual practice teaching experiences gave them confidence in the effectiveness of the targeted instructional approaches, and confidence in their own abilities to enact them. Similarly, the majority of coaches indicated the coaching sessions were helpful in preparing them for their roles as

mentor teachers. Institute outcomes also revealed that participants placed high value on opportunities to practice newly learned strategies and approaches.

Digital or conventional? Impact measurements and expectations of STEAM-pre-service teachers in a German Outreach Lab

Michaela Maurer*, Didactic Biology, Carl von Ossietzky University Oldenburg, Germany

ABSTRACT

Inquiry-based learning provides innovative 21st-century methods for students in science classes. Outreach laboratories at universities or science centers offer the creative learning environment required for inquiry learning. These laboratories also offer interfaces between theory and praxis for pre-service teachers (PST) where essential scientific competencies can be taught. During the COVID-19 pandemic, different concepts [with students (analog/digital) and without students (fellow students only)] were developed to explore expectations, motivational skills, and emotions as essential features of learning success. Overall, 64-Master-PST completed a paper-and-pencil questionnaire at two testing times (quasi-experimental pretest/posttest-design). Based on psychometric measures, I evaluated the latent variables flow/concern, state emotion and science motivation. I also used a shortened questionnaire to capture the Computer-Related Self-Concept and open questions to extract PST's expectations. Additional 58-Bachelor-PST completed an extended version of the Computer-Related Self-Concept and voiced expectations of a digital outreach laboratory in open questions. Flow and state emotions differed between concepts with and without students. Science motivation remained stable across different concepts. Expectations were often controversial and demonstrated that digital outreach laboratories produce high hopes and even higher hurdles. High hopes are particularly connected to digital literacy, which the use of digital platforms may adequately support.

From Remote to In-Person Learning: Changes in Teaching Resources Used by Preservice Secondary Science Teachers

Donald McNish*, University of California, Santa Barbara, USA
Matthew Bennett, University of California, Santa Barbara, USA
Royce Olarte, University of California, Santa Barbara, USA
Valerie Valdez, University of California, Santa Barbara, USA
Cameron Dexter-Torti, University of California, Santa Barbara, USA
Liliana Garcia, University of California, Santa Barbara, USA
Sarah Roberts, University of California, Santa Barbara, USA
Julie Bianchini, University of California, Santa Barbara, USA

ABSTRACT

During the COVID -19 pandemic, the rapid switch to remote learning left many teachers unprepared for adapting content and provided additional challenges for preservice teachers to overcome as they learned their craft. Little work exists concerning the experiences of these preservice teachers as they return to in-person instruction. Building on previous work, we examined resources preservice science teachers utilized by comparing preservice experiences from a remote/ hybrid cohort with preservice teachers from a cohort returning to in-person

learning. A framework grounded in situated learning and resources for teaching considered the context of learning and use of High Leverage Practices as resources. We evaluated how preservice teachers utilized resources in different learning environments and impacts on reform-minded teaching. We qualitatively analyzed interviews from 19 participants over two years. Findings showed that preservice teachers used similar tools regardless of classroom format, though frequency, tool adaptations, and connections to CCCs and SEPs were clearer for the in-person cohort. We argue that resources used by preservice teachers are not necessarily independent from one another and can shift depending on context. Future teachers will need to utilize experiences and reform-based practices to counter trauma, provide support, and engage their students for years to come.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Chemistry Learning and Teaching: Contexts, Characteristics, and Interactions
4/21/23, 9:00-10:30, Blvd C (L2)

Factors influencing formative diagnostic skills of pre-service chemistry teachers

Marc Rodemer*, University of Duisburg-Essen, Germany
Stefan Rumann, University of Duisburg-Essen, Germany

ABSTRACT
The diagnosis of student ideas is part of the everyday work of a teacher. In the course of their studies, pre-service teachers mainly learn summative diagnostic skills in the form of grading student products. However, especially in the teaching of natural sciences, the spontaneous reaction to student ideas is the decision-making basis for appropriate teaching, which is why formative diagnostic skills are considered an important lever for teaching quality (Carlson et al., 2019; Park & Oliver, 2008). In this project, we investigated factors that influence pre-service chemistry teachers' formative diagnostic skills. Findings show a generally poor agreement between pre-service teachers' judgements of student products and a corresponding rubric. Differences occur mainly in the diagnosis of conceptual (productive) errors and spelling (unproductive) errors with significantly higher judgement accuracy for productive errors. Results call for a stronger emphasis on training formative diagnostic skills during university education of pre-service teachers.

Comparing Assessments of Instructional Quality by Chemistry Teacher Candidates and their Domain Specific Advisors

Benjamin Heinitz*, Leibniz University Hannover, Germany
Andreas Nehring, Leibniz University Hannover, Germany

ABSTRACT
Improving instructional quality is a key aspect of science teacher education. In order to give feedback to teacher candidates, domain specific advisors present and discuss their views on instructional quality of science lessons held by teacher candidates. To guarantee a comparable

education for teacher candidates, it appears necessary to foster instructional quality in a comparable manner. This includes the perspective of domain specific advisors as well as teacher candidates. So far, little is known about the understandings of good teaching and focusses in professional vision while evaluating instructional quality in science teacher education.
In this study, we compare evaluations by 17 teacher candidates and 17 chemistry specific advisors (Authors, submitted). For this purpose, we used a video-taped chemistry lesson in a narrative interview setting. All participants were asked to rate the instructional quality. We coded and quantified the data using content analysis techniques. The results showed strong inter- and intra-group differences in the choice and rating of criteria and the overall grading. This presentation goes into further detail about the most prevalent differences in ratings and highlights difficulties that might impair teacher education. Our goal is to highlight potential problems and improve transparency for teacher candidates and their advisors alike.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Science Teachers' Understanding and Implementation of the Next Generation Science Standards
4/21/23, 9:00-10:30, Salon A3 (LL)

A Content Analysis of Next Generation Science Standards Alignment Messages
Jamie Tanas*, University of Iowa, USA
Gavin Fulmer, University of Iowa, USA

ABSTRACT
Standards-Based Reforms like the Next Generation Science Standards (NGSS) are written at the national level and must pass through several layers of the educational system before reaching teachers and students in the classroom. At each level, the NGSS are translated and interpreted for stakeholders. Study of the effects of the NGSS on teaching and learning must attend to the translation of standards at each of these levels. This work focuses on the analysis of NGSS alignment messages directed at teachers through practitioner literature. Teachers will receive and interpret these messages to inform their enactment of the NGSS in the classroom. This content analysis of 185 practitioner articles finds that there is some agreement around alignment to the Performance Expectations of the NGSS, however, there are other referents for alignment among all three dimensions. Additionally, broader NGSS reforms were coded for and the language used to represent these reforms was analyzed. Findings indicate variability among key reforms represented and a lack of clarity in the definition of reforms. This work has implications for those involved in NGSS teacher development and curriculum design.

The Role of Professional Learning and Enactment Experience in Teaching Storyline Curricula: Nationwide Survey Results
Benjamin Lowell*, Boston College, USA
Renee Affolter, Boston College, USA
Katherine McNeill, Boston College, USA

Caitlin Fine, Metropolitan State University of Denver, USA

ABSTRACT
High-quality, freely available curricular materials can help teachers to implement instructional reforms. Without professional learning (PL) teachers might do so in traditional ways. Free materials reduce adoption costs but make it difficult to know who is using them and how they are being taken up. Consequently, we conducted a nationwide survey to understand who has used OpenSciEd, a free storyline curriculum. We investigated respondents' OpenSciEd teaching and PL experience, their instructional beliefs, and how they customized the curriculum. Using ANOVA and chi-squared tests, we found teachers fell into three groups: no PL and some enactment experience, some PL and enactment experience, and more PL and enactment experience. Qualitative analyses of their customizations showed that the group of teachers with the most PL and enactment experience were most likely to demonstrate strong understanding of the key goals of OpenSciEd and practices aligned with those goals. Teachers with less experience considered OpenSciEd through the lens of existing instructional approaches or showed a novice understanding of OpenSciEd. These results demonstrate the importance of attending to how teachers take up free curricular materials and the need to provide high quality PL to support teachers' implementation of the instructional reforms built into these materials.

"By now I haven't told them about insulin/pancreas?": Veteran teacher grappling with NGSS teaching.

Hildah Makori*, Michigan State University, USA
Consuelo Morales*, Michigan State University, USA
Irene Bayer*, Michigan State University, USA
Tania Jarosewich*, Censeo Group, USA
Maria Salinas, Michigan State University, USA

ABSTRACT
The goal of NGSS is to move away from teaching that is based in transmission and memorization of concepts to sensemaking. However, teaching in ways that engage students in sensemaking is challenging since inservice teachers tend to teach the way they have taught. Specifically, inservice teachers have strongly established teaching practices due to many years of teaching experience, generally patterned with traditional forms of teaching. This study seeks to understand how one veteran teacher grappled with NGSS teaching, while being supported through weekly virtual professional learning (PL), and what supported or constrained efforts towards change. The paper utilizes the ideas of habitus and structure to examine the role of long-term professional learning in changing teaching practices. Data included classroom observations, PL video recording, teacher surveys, and interviews. Findings show that sustained PL is a structural support that helped the teacher towards new ways of teaching. However, findings also show that other structures such as deeply ingrained traditional habitus of science teaching and assessments countered the PL. This countering indicates that change of habitus requires time and multiple supportive structures that align with NGSS teaching. The findings have implications for how teacher educators may more effectively support teachers in professional learning.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Administrators and Teacher Leaders Support of Science Teacher Learning
4/21/23, 9:00-10:30, Salon C7-8 (LL)

Identifying Impacts of Administrative Support on Physics Teachers' Professional Learning

James Hancock II*, Alma College, USA
Jack Poling, Alma College, USA

ABSTRACT
There is an overwhelming consensus that sustained opportunities for teachers' professional learning is critical for student success, but due to the COVID-19 pandemic, the nature, substance, and format of K-12 teachers' opportunities for professional learning necessarily shifted. District administrators, focused on maintaining the safest possible learning environment, responded to local health considerations and policies and necessarily made decisions about district-provided professional development. These decisions impacted teachers, and through this qualitative case study research we sought to better understand how high school physics teachers' perceptions of administrative support during COVID-19 impacted their opportunities for professional learning. We analyzed interviews with four veteran physics teachers and found that all four were able to succinctly name the problems they faced during the 2020-2021 school year, but the ways in which they felt supported by administrators to address their problems was varied, yet impactful. The four cases we present serve as reminders that 1) teachers are often acutely aware of their own needs, 2) teachers can serve as resources to others within the building and district, and 3) developing and maintaining an environment of value and support for continued professional learning is helpful in creating a culture centered on instructional excellence.

Differences in STEM Teacher Education Needs According to School-Level and Geographically Diverse Administrators

Doug Ball, Utah State University, USA
Kellie Yates, Utah STEM Action Center, USA
Soojeong Jeong, Utah State University, USA
Tami Goetz, Utah STEM Action Center, USA
Colby Tofel-Grehl*, Utah State University, USA

ABSTRACT
This paper shares findings of a statewide stakeholder input process focused on developing teachers that are highly qualified within their STEM disciplines. Utah educators, administrators, and researchers met to identify various potential needs and areas for growth that could foster and support teacher development across the state, particularly within our rural districts. From these focus groups, we developed and deployed a survey for administrators at the school level to provide feedback to inform a statewide teacher education effort. Findings indicate that

administrator needs are very different between rural and urban parts of the state, as well as between secondary and elementary levels. Compared to non-rural, the rural administrators were much less likely to give priority to expecting their teachers to become more familiar with the new state STEM standards and the accompanying three-dimensional (3D) aspects of the newly adapted science standards. This was also the case for elementary administrators compared to secondary administrators' priorities. Furthermore, rural administrators tend to prioritize giving recruitment priority to their applicants into the program and not basing admittance into the program on district size.

Enacting Teacher Leadership: How teacher leaders influence others and understand leadership in an online community

Preethi Titu*, Kennesaw State University, USA
Fatma Kaya, Kent State University, USA
Gregory Rushton, Middle Tennessee State University, USA
David Yaron, Carnegie Mellon University, USA
Chinmay Kulkarni, Carnegie Mellon University, USA
Wei Zhu, Stony Brook University, USA

ABSTRACT
Teacher empowerment entails the sharing of power which gives teachers legitimacy to take on leadership roles and to participate in the leadership process, with the goal of improved teaching and learning practices (Lai & Cheung, 2014). Online professional development (PD) programs support teachers with a more personalized experience where teachers can pursue learning that are better aligned to their interests and needs. In our PD, educators work together with a community-centric approach to teacher change, teacher empowerment and to better prepare learners to participate in the STEM workforce, where science teachers led other teachers through an online professional development medium that not only helped in sharing best practices but also enabled them to identity who they are while enacting leadership practices. This study attempts to identify how teacher leaders (TLs) influence fellow teachers while engaging in professional learning through online PD and the conceptualization of their leadership. The participants in this study are five AP Chemistry teachers. Based on the interview data of TLs and the analysis of their small group interactions, the findings indicate how teachers were able to manifest their leadership ability by negotiating relationships and exerting influence while engaging in professional learning.

Science Teacher Leadership: Practices leading to empowerment and equitable opportunities in and beyond the classroom.

Tammy Moriarty, Stanford University, USA
Preetha Menon, Stanford University, USA
Brandi Cannon, Stanford University, USA
Janet Carlson*, Stanford University, USA

ABSTRACT
This study aims to describe the processes of teacher leadership development in a fellowship focused on instructional leadership in science. This paper is based on teacher fellows' projects in the second year of their fellowship as part of an individual leadership growth plan. Based on

conceptual frameworks of instructional leadership and sociocultural theory of learning, we used a multiple case study approach to examine how 14 teachers developed leadership in the service of equitable opportunities in high-quality science instruction. We describe a qualitative method that includes temporal and micro-level analysis of the teachers' projects to highlight their growth and development as teacher leaders. Preliminary research shows three emerging models of teacher leadership to support equitable opportunities in science, where the teacher leaders broker their support for fellow teachers, translate leadership practices to give agency to students and teachers, and transform leadership practices for empowerment. This study adds to our understanding of instructional leadership to support equitable opportunities by highlighting the contextual details which support leadership growth and development and the importance of prioritizing leadership development of science teacher leaders to lead to a more systemic impact in school systems.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Identity and belonging in science education across varied spaces
4/21/23, 9:00-10:30, Salon A4 (LL)

Contemporary Colonization: How Gentrification of Urban Communities Impacts Science Education in the new "Urban" Schools

Kendra Sobomehin*, Stanford University, USA
Bryan Brown*, Stanford University, USA
Tamara Sobomehin*, Stanford University, USA

ABSTRACT
The term ‘Urban' is often synonymous with poverty, multilingualism, and students of color. However, schools in urban communities often serve divergent populations, a group of middle-class families, and an increasingly multilingual and multicultural student population. This review article of n =203 manuscripts examines 30 years of research on teaching science in urban schools. The consensus of research identifies how policy in science education has failed to address the realities of urban schools, challenges educators to create cultural bridges that contextualize science, and pushes for an expanded conception of science curriculum and practices. An assessment of the state of the field suggests that there is a need for expanded theoretical lenses that adopt an intersectional approach to urban science. Additionally, the failure to use technology as a mediator for producing equitable learning environments also limits the effectiveness of modern approaches to science teaching and learning.

Recognition as an equal or superior being? Science identity and Rousseau's theory of self-love

Wonyong Park*, University of Southampton, United Kingdom
Lucy Avraamidou, University of Groningen, Netherlands

ABSTRACT
In recent years, there has been increased attention to the role of recognition in shaping individuals' science identity. Research suggests that one's science identity is formed through complex interactions of personal histories, race, agency, gender, emotions and positionalities and particularly the experience of (mis)recognition. Recognition refers to "how individuals are recognized by others as certain kinds of people" and is influenced by sociopolitical contexts such as cultural norms, values, beliefs and stereotypes. The purpose of this paper is to address these gaps in the science identity literature and propose an extended conceptualization of recognition in science education. We draw on the theory of self-love and recognition articulated by Jean-Jacques Rousseau (1712-1778) in his major works such as Discourse on Inequality and Emile. This conceptual paper examines Rousseau's own works as well as their modern interpretations by commentators to explore some ramifications for science identity research and practice. We use Rousseau's concept of amour propre, a desire to seek esteem, approval, love or recognition from others, to highlight how his theory of recognition provides a novel lens to study science identity and individuals' experiences of recognition that can inform future research in this area.

Promoting science capital in young Arabs in Israel
Wisal Ganaiem*, Technion- Israel institute of technology, Israel
Shulamit Kapon, Technion- Israel institute of technology, Israel

ABSTRACT
The study employs a constructive (anti-deficit) approach that focuses on the ability of students from nondominant communities in STEM to actively change their situation and position in and through science. We examine the Gap-Year Program led by a grassroot non-profit Arab organization in Israel, which recruits outstanding Arab high school graduates and trains them to be young Arab instructors (YAIs) of STEM outreach activities in Arab schools all over Israel, through professional development in STEM content and pedagogy, as well as leadership and social activism. The goal of this study was to explore and suggest patterns for supporting the emergence of science capital in young adult members of the minority community of Arab citizens of Israel. The research questions were: (1) What are the important features of the program as perceived by its participants? (2) What is the impact of the program on its participants as they perceive it? Semi-structured interviews were conducted with the 2015 cohort of the program (N=9). The research approach combined phenomenography with grounded theory. The findings point to the central role of agency as an expression of science capital and as a means to enhance it, in particular for students from nondominant communities in science.

In This Space, I Got You: Exploring the Coding Trajectories of Two Black Boys
Ti'Era Worsley*, The University of North Carolina at Greensboro, USA

ABSTRACT
Learning opportunities are informed by one's connections to specific places. Those experiences determine connections developed and can be informed by space/time spent in a place, types of learning that occur, or physical/mental boundaries. This study looks at how an

informal STEM educator supported two Black boys learning opportunities in coding as they critically reflected and took political action in coding their games, specifically looking at how the establishment of politicized trust between the educator and youth supported their development of critical agency. By using socio-spatial relationalities and politicized trust I explore how place, materials, and educator-youth interactions supported youth in coding. Participatory design research, analyzed in grounded theory is used to map the three phases of Donovan and Jabria's learning trajectories. These phases include; tensions to coding with scratch, pivotal interaction with the educator, and development of critical agency. Four main points emerged as key to youth navigating coding; continuous access to materials, sustained engagement to reimagine possibilities, understanding that all disengagement is not equal, and being explicit in communicating expectations followed by concrete action.

Strand 15: Policy, Reform, and Program Evaluation
Symposium: Scaling up innovative pedagogies in science education: A national perspective
4/21/23, 9:00-10:30, Salon A5 (LL)

Scaling up innovative pedagogies in science education: A national perspective

Anat Zohar*, Seymour Fox School of Education, Hebrew University of Jerusalem, Israel
Dana Vedder-Weiss*, School of Education, Ben Gurion University of the Negev, Israel
Rotem Trachtenberg-Maslaton*, School of Education, Ben Gurion University of the Negev, Israel
Hagit Kuperstein, School of Education, Ben Gurion University of the Negev, Israel
Aliza Segal, School of Education, Ben Gurion University of the Negev, Israel
Eran Zafrani*, Weizmann Institute of Science, Israel
Anat Yarden, Weizmann Institute of Science, Israel
Yehudit Dori*, Faculty of Education in Science and Technology, Technion, Israel
Orit Herscovitz, Faculty of Education in Science and Technology, Technion, Israel
Jonathan Osborne, Stanford Graduate School of Education, Stanford University, USA

ABSTRACT
The goal of this symposium is to discuss the immense challenge of scaling up innovative pedagogies, including those that promote critical thinking and argumentation. Policy papers published worldwide point to the teaching of students' thinking as one of the key objectives of 21st-century education. This is also true in [COUNTRY], where in recent decades, several policy papers were published, and several reforms and projects have been attempted. Yet, the need to implement pedagogies that highlight the development of students' thinking and deep understanding on a wide scale, and improve teachers' knowledge, is still far from being fulfilled. The question of how to reform extant pedagogies at scale assumes even greater prominence, as school systems face increasing demands for divergent changes, which impinge upon and break away from traditional and established schooling norms and practices. The four studies that compose the basis for the discussion in this symposium attempt to replace the dominant way of teaching and learning according to a transmission of information

approach. These studies were conducted in a centralistic educational system, where the Ministry of Education dictates a fixed curriculum, issuing "top down" regulation regarding instruction, assessment and teacher education policies, and enforcing them through strict supervision.

Concurrent Session 12
4/21/23, 10:45-12:15

Roundtables Session 3
4/21/23, 10:45-12:15, Salon A5 (LL)

Topic 1: Student and teacher identity

Strand 11: Cultural, Social, and Gender Issues
Social Justice and Identity in Science Teaching: Perspectives of White Men Teaching Science
Maizie Dyess*, UNLV, USA
Katie Wade-Jaimes, UNLV, USA

ABSTRACT
This proposal describes the results from a social justice institute designed for teachers. As part of the institute, a small group of teachers met to explore and analyze the development of social justice science teaching identities. Qualitative data analysis of interviews and field notes revealed several important themes for understanding how teachers conceptualize social justice within the classroom. Many of the teachers indicated that engaging in the conversations supported within the institute strengthened their understanding of systemic barriers in science education as well as their agency to effect change in education. Additionally, the conceptualization of these science teaching identities was explored specifically in white men who teach science. The results challenge teachers to disrupt narratives about what and where science is in order to recreate a culture of science that is both visible and accessible to populations that have been historically excluded from science and science education.

Strand 11: Cultural, Social, and Gender Issues
How Indigenous Islanders Identify With STEM
Jonathan Boxerman*, WestEd, USA
Sharon Nelson-Barber, WestEd, USA
Kimberly Nguyen, WestEd, USA

ABSTRACT
This 5-year multi-institution research and implementation project examines how Indigenous islanders maintain identity and sense of belonging to their heritage culture as they develop STEM identities and a sense of belonging to the STEM community. To understand how this happens, each year a cohort of high school and undergraduate students from Guam experience a range of STEM programs designed by university faculty to increase their sense of belonging and identification . In June, near the start of the new year of programming, our research team conducted in person interviews with many Chamorro students about their cultural heritage and how they perceive it intersects their everyday experiences and their perceptions of STEM and the STEM programming. The hypothesis states if Indigenous students explore STEM research possibilities tied to their own island contexts and participate in cohort building and mentoring activities, then students will increase their sense of belonging

to their heritage cultures and to the STEM community. By supporting students in the program to carry out scientific research through community-based and culture-based STEM programs and activities, students appear to identify with and feel an increased sense of belonging to their heritage culture and to the STEM community.

Strand 1: Science Learning: Development of student understanding

The Role of Children's Racial Identity and it's Impact on their Science Education

Lisa McDonald, Teachers College, Columbia University, USA
Felicia Mensah*, Teachers College, Columbia University, USA

ABSTRACT

In the context of schooling, there is a disconnect for students between home and school. The structure of a classroom consists of the social relationships that children have with their peers and teachers. Racial identity is also a valuable aspect in the construction of knowledge as children learn science. In the literature, the racial identity of young children and science and how it pertains to students' learning aren't acknowledged. Young children need to be able to see themselves in science regardless of their race or ethnicity. Critical race theory (CRT) examined and helped situate the context of race with children's identity. The sociocultural theory describes how a community of practices helps students develop their identities. The participants of this study included ten children in grades 3 through 5 who attended a diverse urban school located in New York City and their parents (10 parents). Qualitative research methodologies allowed both children and parents to share their perspectives on their experience with science and ‘difficult' topics that pertain to race and/or skin color. The research design was mixed methodologies to draw from narrative inquiry and quantitative methods from the Likert surveys.

Topic 2: NOS Goals and Strategies

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

The development of an interdisciplinary learning environment with a historical context for chemistry lessons

Natalie Ahne*, University of Kassel, Germany
David Di Fuccia, University of Kassel, Germany

ABSTRACT

The focus of this project is the development of a digital learning environment that aims to achieve various goals at the same time: On the one hand, it is intended to help students of the first high school year to gain knowledge about the nature of the natural sciences, hence meta-knowledge about chemistry using aspects of the history of chemistry. On the other hand, teachers will be offered an opportunity to use a digital medium in the classroom which not only promotes media skills, but also enables learners to develop chemical meta- and content-knowledge. In this way, the learners are to be made aware of the scientific methods (Barke, Harsch, Kroeger, & Marohn, 2018), by placing chemical contents, that are already taught in the German curriculum, in a meaningful historical context. The aim is to convey learners an authentic impression of the history of science and, at the same time, about the natural scientist

as a person, while learning content knowledge about the acids and bases. To present the integration of history in the chemical context as authentically and profitably as possible, an interdisciplinary approach is pursued.

Strand 13: History, Philosophy, Sociology, and Nature of Science
American Scientists' Views about Nature of Science in the Context of Socioscientific Issues
Rola Khishfe*, American University of Beirut, Lebanon

ABSTRACT
The purpose of this study was to examine scientists' views about three nature of science (NOS) aspects (subjective, tentative, and empirical) in the context of three controversial socioscientific issues (SSI) and whether these views vary depending on the SSI contexts in which the questions were framed. Participants were 102 scientists in distinct science disciplines across the US. They completed a questionnaire that consists of three scenarios addressing controversial SSI about genetically modified food, global warming, and water fluoridation. The investigation used a qualitative design to compare the responses of scientists across the different SSI contexts. Results of this study showed that these scientists disclosed both less accepted and more accepted views of the three NOS aspects depending on the context of the question, which suggested that the scientists' views about NOS are context dependent. The disparity between the SSI contexts given and scientists' own scientific contexts led to their inability to use their NOS understanding appropriately to evaluate SSI due to the multi-perspectives involved in SSI. Therefore, it could be that these scientists are adhering to their science ideas and may not be putting their knowledge in practice in order to use their NOS understanding in the context of SSI.

Strand 13: History, Philosophy, Sociology, and Nature of Science
High School Students' Images of Science: A Decade into NGSS
Catherine Wagner*, University of Notre Dame, USA
Matthew Kloser*, University of Notre Dame, USA
Michael Szopiak*, University of Notre Dame, USA

ABSTRACT
Young people's views of science have been studied for multiple decades, revealing varied perspectives of the scientific enterprise. A decade into NGSS, we seek to explore the range of students' views and their relation to discrete NOS tenets, science as practice, or other models entirely. This experimental study seeks to identify current high school students' images of science and the scientific enterprise in an unprimed, informal context. Forty high school students answered open-ended questions about their images of science. Their responses were coded according to a three-part coding scheme drawing upon the NOS literature, science as practice framework, and emergent codes. One-fourth of the responses aligned with the NGSS practices, whereas only 11.5% reflected NOS tenets. While the majority of student responses do not naturally gravitate towards distinct tenets presented in the literature, students do frame science as practice – identifying ‘research' most commonly – at a large grain-size. These findings point to the likely need for more intentional discussions about the practices in which students engage and opportunities for students to discuss and revise their images of science,

as well as for researchers to examine the methodology used to collect students' images of science in informal, non-school settings.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Socioscientific Literacy: An Emancipatory Goal for Science Education
Kory Bennett*, University of South Florida, USA
Dana Zeidler, University of South Florida, USA

ABSTRACT
We are immersed in metaphorical and physical systems constructed from dominant ideologies, by dominant groups of people. Even with modifications, these systems remain in place, and continue to favor particular people over others. Injustice, inside and out of the classroom, should be a focal concern for science educators. If relatively few students join a scientific community, we must interrogate the goals of science education. Here, we question the fitness of a central goal of science education, scientific literacy (SL). The focus of this philosophical investigation was to use deconstruction and conceptual analysis to (1) scrutinize SL to reveal concealed characteristics of the concept, (2) examine functional scientific literacy (FSL) in relation to SL, to identify the boundaries between the two concepts, and (3) utilize findings to expand FSL toward a reflexively positioned, student-driven, emancipatory goal for science education, called Socioscientific Literacy (SSL). This goal promotes the reflexive cultivation of abilities to operate socioscientific cognition to grapple with, and seek solutions for, a vast diversity of complex socioscientific and everyday human issues. Furthermore, the development of SSL requires opportunities to cultivate abilities to recognize systemic, hegemonic, oppressive influences, and to formulate ways to act justly in response to these influences.

Topic 3: Climate change awareness and conservation

Strand 14: Environmental Education and Sustainability
Examining secondary students' awareness of bee conservation in the U.S.
Rita Hagevik*, UNC-Pembroke, USA
Kathy Trundle, Utah State University University, USA
Kaitlin Campbell, UNC-P, USA
Katherine Vela, Utah State University, USA
Laura Wheeler, Utah State University, USA
Michelle Parslow*, Utah State University, USA
David Joy, Utah State University, USA

ABSTRACT
Recent surveys focused on adults' understanding of pollinators while excluding school-age students. Thus, this study focused on secondary students' knowledge about bees and attitudes toward protecting them. Results from a Qualtrics survey about bees and other pollinators indicated that students underestimated the number of native bee species and overestimated the species of honeybees. Despite this finding, students were able to correctly identify a bee from non-bee species. Students often misidentified native bees common to the U.S. that have colors other than black and yellow, and they had difficulty identifying a

honeybee, which they believed to be an endangered species. The native bumblebee was misidentified as the non-native honeybee. Even though students were cautious of being stung or somewhat afraid of insects, they overwhelmingly expressed a strong desire to protect bees and other pollinators. It is important to understand what we desire to conserve. These misconceptions about bees provide a foundation for science educators to identify conceptual gaps and help students develop scientific understandings of these environmentally important organisms. Pollinators, as indicator species, are linked to overall environmental health including climate change. This study clearly indicates the need to develop school and outreach programs related to native bees and conservation.

Strand 1: Science Learning: Development of student understanding

Exploring the critical reading of a climate change topic using multimodal texts

Xavier Fazio*, Brock University, Canada
Tiffany Gallagher, Brock University, Canada

ABSTRACT
A qualitative case design research study was implemented with adolescents learners using a think-aloud observational protocol focused on reading two multimodal texts on climate change from contrasting viewpoints. The participants completed a prior knowledge assessment and survey of technology used to assess potential mediating factors. Survey and observational data will be presented as participant profiles from the intervention. Findings showcase the effect of participants' background knowledge, emotional elicitation of text features, and impact of visual images on participants' comprehension in response to the contrasting multimodal texts. Data analyses revealed that there is an interconnected and nuanced relationship amongst many text and individual learner factors when adolescents engage in critical reading of SSI multimodal texts. These findings begin to contribute to the lexical aspects of multimodal text comprehension by adolescent learners and point to how to incorporate different forms of texts into science classroom instruction when teaching about SSI. This research provides direction for future science education research that investigates critical reading of complex socioscientific topics as presented in multimodal texts with adolescent learners.

Topic 4: Curriculum and Implementation Studies

Strand 8: In-service Science Teacher Education

Using a Teacher Learning Progression of Instructional Skills to Examine Geospatial Curriculum Adoption

Danielle Malone*, Washington State University Tri-Cities, USA
Kate Popejoy*, Popejoy STEM LLC, USA
Molly Weinburgh*, Texas Christian University, USA
Kristen Brown, Texas Christian University, USA
Jonah Firestone, Washington State University Tri-Cities, USA
Alec Bodzin, Lehigh University, USA
Thomas Hammond, Lehigh University, USA

ABSTRACT
The research described here reports on geospatial professional development and curriculum development with twenty-three high school teachers in STEM-related disciplines across four states: Washington, Texas, Delaware, and Pennsylvania. Using a teacher learning progression for geospatial technology integrated curriculum, we sought to identify salient teacher characteristics that explain the relative differences in outcomes and develop a visualization of teachers' pathways towards independent, sustaining workflow. This research aims to answer the following questions: (1) What are the characteristics of our most successful, innovative teachers who can independently develop and implement STEM-related, curriculum-aligned geospatial instruction with GIS? (2) What factors contribute to STEM-related teachers' relative lack of progress in creating and implementing curriculum-aligned geospatial instruction with GIS? Our preliminary findings suggest that teachers with previous experience with geospatial technologies or who are actively using technology as a tool for instruction progressed towards an independent and self-sustaining level. Even after two consecutive years of involvement, teachers who stayed close to the entry-level struggled with barriers related to technology and curricular constraints that leave little room for teacher autonomy in their instruction.

Strand 7: Pre-service Science Teacher Education

Exploring the use of a math modeling-based activity to introduce the idea of energy

Cynthia Lima*, University of Texas at San Antonio, USA

ABSTRACT
This research study explores the use of a Math-modeling based activity to support teacher candidates' development of the idea of energy in the context of an inclined plane. This study hypothesizes that using a math modeling activity could offer an opportunity to develop a deep understanding of the idea of energy. This is, to identify key kinetic and potential energy observable variables and establish relationships between them. The activity was implemented with a group of 20 bilingual teacher candidates enrolled in a teacher preparation program as part of the Science Methods Course. The qualitative analysis showed the development of a relationship between the ramp setting and the car's speed, and science and engineering practices, including planning and carrying out investigations, designing solutions, communicating information, and arguing using evidence. However, limited use of data to support claims, suggests the need for further research to identify approaches to support teacher candidates' understanding and implementation of this practice. The alignment between the emergent knowledge and practices with the NGSS demonstrates the potential of the activity to develop teacher candidates' content knowledge in a way that supports their pedagogical content knowledge, and introduce them to three-dimensional learning envisioned in the standards.

Strand 15: Policy, Reform, and Program Evaluation

Investigating the Effect of Classroom Facilities and Technology on Teachers' NGSS Aligned Instruction

Tess Bernhard*, University of Pennsylvania, USA

ABSTRACT
In reflecting on the implementation of the NGSS over the past decade, national survey data suggests there is still progress to be made in terms of teachers adopting instructional practices that are aligned with the standard's vision of more student-centered classrooms. This study uses propensity score matching methods on a large national survey of teachers (NSSME+) to understand whether two possible contextual variables have any detectable causal effect on teachers' self-reports of NGSS-aligned instructional practices. The first variable, access to a high-quality classroom facility, was seen to have a significant impact on teachers' instructional alignment to the NGSS. The second variable, access to 1:1 devices as classroom technology, did not show the same significant effect. These results emphasize the critical importance of classroom infrastructure to science education reform efforts. This indicates that classrooms need to be outfitted properly if students are going to take a more active role in science learning, and that the increase in 1:1 devices seen throughout the pandemic is unlikely to remedy the lack of NGSS alignment amongst teachers in poorly outfitted schools.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
SC-Organized Paper Set: Students Ways of Thinking
4/21/23, 10:45-12:15, Salon C5-6 (LL)

Relationship between middle school students' talks, gestures, and group outcomes in collaborative science problem-solving activities

Arif Rachmatullah*, SRI International, USA
Nonye Alozie, SRI International, USA
Hui Yang, SRI International, USA

ABSTRACT
Despite extensive research on collaboration and multimodality in science education, limited studies have explored how students use multiple modes, such as talk and gesture, in a collaborative setting. Drawing on social-semiotic theory, the current study examines the differences in the use of talk and gesture during collaboration based on the quality of artifacts/solutions that student groups generated. A total of 15 three to five-member groups of middle school students participated in a set of clinical collaborative science problem-solving activities. Six groups (three low- and three high-performing groups) were selected for further analyses. The data consisted of successive statements in student conversations that were coded with different types of talk and gestures. Epistemic Network Analysis (ENA) was used to analyze the data. The results revealed that high-performing groups were significantly different from low-performing groups in the use of higher cognitive engagement and collaborative regulation talks. We did not find a significant difference in the use of gestures. However, we found that high-performing groups tended to use higher cognitive engagement and collaborative regulation talks together with or followed by representational and pointing gestures. These findings underline the significant functions and affordances of talk and gesture in collaborative science activities.

Investigating secondary school students' knowledge about and acceptance of evolution, personal religious faith, and denomination

Roxanne Gutowski*, Institute for Biology Education, Faculty of Mathematics and Natural Sciences, University of Cologne, Germany
Helena Aptyka, Institute for Biology Education, Faculty of Mathematics and Natural Sciences, University of Cologne, Germany
Jörg Großschedl, Institute for Biology Education, Faculty of Mathematics and Natural Sciences, University of Cologne, Germany

ABSTRACT
Evolution and its key mechanisms such as natural selection are fundamental to understanding biological change. Still, students' reasoning about natural selection reveal persisting misconceptions about evolution. Misconceptions in the form of lacking scientific knowledge about evolution are negatively related to the acceptance of evolution. Research on this relation and further associated factors such as personal religious faith and denomination is inconsistent. This cross-sectional study attempts to further elucidate the interplay between knowledge about and acceptance of evolution, and personal religious faith regarding different groups of denominations (e.g., Catholics) by examining N = 172 German upper secondary school students. Results show differences in knowledge about evolution, acceptance of evolution, personal religious faith, and the use of key concepts by different denominations but not regarding the use of misconceptions. Analyses reveal that denominations were predictive for knowledge about evolution and personal religious faith predicted acceptance of evolution. Our study provides new insights into the role of denominations and personal religious faith for knowledge and acceptance. It indicates that the type and strength of these variables do not exhaustively explain the variance in knowledge about and acceptance of evolution. Therefore, future research should consider other related factors such as perceived conflict.

Middle Schools Students' challenges performing the Control-of-Variables Strategy: Recognizing errors in third-party experiments is easier.

Linda Hämmerle*, University of Vienna, Austria
Alexander Bergmann, University of Leipzig, Germany
Andrea Möller, University of Vienna, Austria

ABSTRACT
Studies found that learners face various challenges during experimentation, especially regarding the Control-of-Variables strategy (CVS). However, most studies use non-practical performance assessment formats. Practical performance is important as challenges and errors could be presented as a starting point for scaffolds or learning of experimentation itself. For the latter, learners must realize that a solution is erroneous. Focusing on experimentation, only few studies have analyzed whether learners recognize errors. Hence, we investigated 1) learners' CVS-challenges during experimentation, 2) learners' capability to recognize CVS-errors in experiments, and 3) whether the recognition varies when identifying one's own or third-party CVS-errors. In an experimental mixed-method study design with middle school students (N = 191, grade 7 and 8) group A conducted an experiment themselves while group B worked with an erroneous third-party experiment. Both groups received instructions on CVS before re-

analyzing the experiments. Analyses were done with the help of photos of the experimental setup and students' lab journals. Results show that especially handling the material is challenging. Interestingly, it is significantly easier for students to recognize errors in third-party experiments than in their own ($p < 0.001$, $r = .57$). Data will be discussed in detail at the NARST conference.

Three types of FIRST mentors: interpersonal skills and STEM career choice

Shahaf Rocker Yoel*, Technion – Israel Institute of Technology, Israel
Yehudit Dori, Technion – Israel Institute of Technology, Israel

ABSTRACT
FIRST—For Inspiration and Recognition of Science and Technology—is a program aimed to motivate young students to pursue a Science, Technology, Engineering, and Mathematics (STEM) career. Based on the Social Cognitive Career Theory (SCCT), this research focuses on characterizing three types of FIRST mentors, their perceptions, their mentees' interpersonal skills, and their STEM career-choices, and identifying differences between the types. The research design is based on the mixed-methods approach, with quantitative and qualitative data collected simultaneously. The participants were 465 mentees, graduates, and mentors, who filled out questionnaires. Interviews were also conducted with 17 mentors. From the analysis of the interviews and the open-ended questions, based on SCCT, 14 categories which characterize the mentors emerged. Differences were found between the FIRST mentor types. The mentors' perceptions were consistent with those of their mentees. STEM career-choice of men is impacted by FIRST more than that of women, while external motivation of women is impacted more than that of men. The theoretical contribution is the application of SCCT in the context of mentor-student interactions in the program. The practical contribution is the demonstration of how mentor-student interactions in the FIRST program contribute to mentees' STEM career choice and interpersonal skills development_.

Strand 4: Science Teaching - Middle and High School (Grades 5-12): Characteristics and Strategies
SC-Organized Paper Set: Cultural and Cognitive Approaches to Student Learning
4/21/23, 10:45-12:15, PDR 2 (L3)

Liberating Students from Anxiety and Underachievement in Flowchart and Algorithm: CTCA a Stitch in Time

Deborah Agbanimu*, 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
Franklin Onowugbeda, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Juma Shabani, Université du Burundi, Burundi

Esther Peter, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Olasunkanmi Gbeleyi, 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
Ibukunolu Ademola, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Yinka Ogunlade, Ekiti State University, Nigeria
Eunice Ikpah, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
Bugoma Suwadu, Université du Burundi, Burundi
Fred Awaah, University of Professor Studies, Ghana

ABSTRACT
Students experience a range of emotions in response to classroom activities and achievement outcomes, which can impact student success. Anxiety is one emotion that students experience, and it can have a negative impact on their performance. This study investigated the effectiveness of CTCA in reducing students' anxiety and underachievement in algorithm and flowcharts. A sequential explanatory (mixed methods) design was used. The study included 185 junior secondary school students from two purposively chosen schools in Lagos State Education District V. The quantitative data was collected using a flowchart and algorithm achievement test and an anxiety scale with reliability coefficients of 0.74 and 0.70, respectively. After the pretest, the experimental group was taught using CTCA and the control group with the traditional teaching method for four weeks, followed by the posttest. Within the study's constraints, the experimental group outshone the control group with the mean achievement score (experimental = 13.94; control = 10.06) and mean anxiety score (experimental = 16.32; control = 21.19), indicating that CTCA is capable of reducing student anxiety and increasing their performance.

Students' knowledge retention in biology through the action of CTCA

Franklin Onowugbeda*, 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
Deborah Agbanimu, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
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Juma Shabani, University of Burundi, Burundi
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Umar Adam, Lagos State University, Nigeria
Adekunle Oladejo, Africa Centre of Excellence for Innovative and Transformative STEM Education, Lagos State University, Nigeria
David Byamungu, University of Burundi, Burundi

ABSTRACT
The goal of this study was to examine the effectiveness of CTCA on students' retention in variation and evolution. Participants were 88 secondary school II students from two purposively selected schools in Lagos State education district V. The variation and evolution achievement test with a reliability value of 0.79 was used to collect the quantitative data. All the 88 students used for the experimental and control groups were given a pre-test achievement to determine the entry level of the students. After the pre-test exercise, the treatment was implemented for four weeks. The experimental group of students received four weeks of instruction by applying CTCA. The control group of students ($n = 43$) learned in the same way as the experimental class, but without any CTCA components. At the end of the treatment phase, all the students were given a posttest on the same evaluative achievement instruments and, a retention test four weeks after the post-test exercise. Results on the ANCOVA output showed a statistically significant difference in the knowledge retention measure [$F(1,85) = 134.51$; $p < .05$]. This implied that CTCA brought about better retention of concepts in variation and evolution than the lecture method.

Investigating Student Systems Thinking While Building and Revising Models

Jonathan Bowers*, Michigan State University, USA
Emanuel Eidin, Michigan State University, USA
Linsey Brennan, Michigan State University, USA

ABSTRACT
There is an increasing recognition of the importance of systems and systems thinking to understand natural phenomena. Systems thinking (ST) proposes that a natural phenomena be viewed as a series of interacting elements that work together to form more complex behavioral patterns. With computational models, students can construct models of systems that include different types of relationships between elements including linear causal chains, collectors and flows, and feedback loops. As past studies demonstrate that students have more difficulty discussing collectors and flows and feedback loops, we were interested in how a new computational modeling unit might support students in discussing these more complex aspects of ST. By developing a new instrument (Systems Thinking in Modeling Analysis Tool), we sought to categorize examples of student discourse around ST based on the types of relationships they were discussing and the complexity of these discussions. Using representative examples from three different student groups during a computational modeling unit, we found evidence of student behavior corresponding to all six indicators of our instrument. Our findings suggest that in this unit, students were more likely to discuss collectors and flows and simple causal relationships and less likely to discuss feedback loops.

Concurrent Session 12, 4/21/23, 10:45-12:15

A Literature Review: Analyzing Barriers Hindering the Implementation of Self-Regulated Learning in the Classroom

Jayme Del Mario*, Texas Christian University, USA
Hong Tran*, University of Georgia, USA

ABSTRACT
Self-regulated learning (SRL) is a goal-directed process in which learners are metacognitively, motivationally, and behaviorally active participants in their learning process. Although studies have shown that SRL is critical for success in academic learning, life, and beyond; many students do not use SRL strategies to drive their science learning. To better understand the circumstances surrounding this unfortunate situation, this literature review reports on 15 studies related to barriers that hinder science teachers from enacting self-regulated learning. We first discuss the role of SRL, explain the rationale for this literature review, provide theoretical frameworks, and then examine the barriers. Findings revealed four primary barriers: scarcity of time, disregards within the curriculum and assessment, lack of training, and teacher's epistemological beliefs in SRL. Finally, we conclude our review by analyzing the relationships between the barriers in light of theoretical frameworks and current research as well as suggest directions for overcoming the barriers.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Teaching Difficult STEM Content
4/21/23, 10:45-12:15, Salon C1-2 (LL)

Fossils, DNA, and Nothing: Evidence of Evolutionary Biology University Students Find Compelling

Sam Skrob-Martin*, Florida State University, USA
Joseph Travis, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT
Recent educational reforms have positioned the development of science proficiency as the end goal of science instruction—that is, students should be able to engage in the disciplinary work of science, especially sensemaking, to create explanations about the natural world (AAAS, 2011; NRC, 2012; NGSS Lead States, 2013). One facet of proficiency in biology is wrestling with ideas of biological evolution: a necessary paradigm for informed sensemaking in biology (AAAS, 2011). Many obstacles encumber evolution education, which previous studies have sought to understand and overcome through understanding the relationships between evolution knowledge, acceptance, and even degrees of religiosity. Although much research has examined how best to support evolution education, little has examined what aspects of evolution education students are receptive to and how they are taking up those ideas. This study aims to identify lines of evidence for evolutionary biology university students find most compelling (if any) before and after taking a capstone evolution course. The findings demonstrate that students have different ideas on evidence for evolution, and these ideas can

change before and after a capstone evolutionary biology course. The significance of these results will be discussed.

Does evolution coursework mitigate, maintain, or exacerbate educational debt? Equity implications in the evolutionary sciences

Gena Sbeglia*, San Diego State University, USA
Ross Nehm, Stony Brook University, USA

ABSTRACT
Monitoring students' ‘educational debt' (education-related disparities produced by decades of historical, economic, and sociopolitical decisions and policies) is an important aspect of equity research. This study: (1) extends Ladson-Billings's (2006) and Van Dusen et al.'s (2022) educational debt frameworks to incorporate the magnitude of learning as a dimension along which between-group, pre-post patterns of change can be evaluated; (2) proposes that this extended empirical framework be used as a tool for courses and departments to quantify educational debt; and (3) analyzes longitudinal patterns of evolution learning and debt mitigation/exacerbation in >3K students over 11 semesters using multiple validated instruments. Using the new framework, we ask: (1) What is the magnitude of educational debt among historically excluded student groups at course entry? (2) What impact does instruction have on educational debt (i.e., mitigated, maintained, or exacerbated)? Overall, 11 semesters of evolution instruction displayed high magnitudes of learning in nearly all cases. Educational debt was not increased for students from any historically excluded race/ethnicity, gender, socioeconomic, or prior biology group. Rather, instruction generally maintained the educational debt, except for prior preparation where debt mitigation occurred. We discuss the implications for equity efforts in biology education.

Understanding the Connection Between Students' Acceptance of Socioscientific Issues and Information Sources

Brock Couch*, University of New Hampshire, USA
Grant Gardner, Middle Tennessee State University, USA

ABSTRACT
Students in today's society have the ability to gain information on science topics from a vast number of sources, which may or may not be vetted by the science community. Within the classroom, socioscientific issues (SSI) can provide students the opportunity to develop their skills in creating solutions for real-world situations, which help them navigate current issues that are new to science. Using latent profile analysis and bipartite networks, we looked at the connection between students' acceptance of SSI and the information sources they use to gain SSI information. Within out sample, we found seven distinct groups of students that had varied acceptance by SSI. A result from this study that should be taken note of is that social media is often the main information source for both undergraduates with high and low acceptance rates. This result could highlight undergraduates maintaining social media networks with individuals that are ideologically similar to them, so they are only interacting with information that does not present different opinions. Another reoccurring result across SSI was undergraduates

indicating academic resources (e.g., academic journals, professors, textbooks) as their main information sources despite having low acceptance rates of SSI.

Assessing College Students' Uncertainty Management in Problem-Based Learning: Development of a Questionnaire Instrument

Jongchan Park*, Arizona State University, USA
Yuli Deng, Arizona State University, USA
Garima Agrawal, Arizona State University, USA
Ying-Chih Chen, Arizona State University, USA
Huan Liu, Arizona State University, USA

ABSTRACT
Researchers have suggested a variety of different individual characteristics that affect the productiveness of problem-based learning (PBL). Uncertainty management has been recently emphasized one of those factors that involve students' metacognitive and regulative engagement in learning. Due to its unobservable and implicit nature, there is a call for a valid instrument to assess students' uncertainty management in the context of PBL. This paper developed a scale for the uncertainty management in problem-based learning that can be used for college students. Then, the structure of the uncertainty management was explored through exploratory factor analysis. The results yielded a three-factor model of the uncertainty management in PBL scale: Perception of uncertainty in learning to solve problems, self-efficacy in uncertainty management and strategy for uncertainty management. Potential future research that can use the instrument developed and validated in this study is suggested.

Strand 7: Pre-service Science Teacher Education
Symposium: Internationalization of Rural Science Teacher Preparation in the United States
4/21/23, 10:45-12:15, Salon C3-4 (LL)

Internationalization of Rural Science Teacher Preparation in the United States

Gayle Buck*, Indiana University, United Kingdom
Sumreen Asim, Indiana University Southeast, USA
Selina Bartels, Valparaiso University, USA
Khadija Fouad, Appalachian State University, USA
Allison Freed, University of Central Arkansas, USA
Robbie Higdon, James Madison University, USA
Lacey Huffling, Georgia Southern University, USA
Jessica Stephenson Reaves, Kennesaw State University, USA
Heather Scott, Georgian Southern University, USA
Ryan Summers, University of North Dakota, USA

ABSTRACT
The scope of science teachers' responsibilities continues to expand to include preparing students for an interconnected world. Among many other things, the recent events related to a pandemic, climate change, and resource management have further demonstrated that being globally literate is a critical need. Globally competent science teachers tailor students' educational experiences to engage in more powerful, relevant, and transformational learning to meet demands and opportunities. Unfortunately, globally competent science teaching is not yet sufficiently addressed in our teacher preparation programs, and teachers enter schools unprepared to address this need. This is particularly concerning regarding preparing teachers for rural schools. This symposium focuses on the need to increase the quantity and enhance the quality of science teacher education initiatives to prepare rural teachers to thrive in an interconnected, interdependent, and complex world. The first section sets up the discussion by establishing the need for internationalization efforts in rural science teacher preparation and exploring current efforts to foster rural teachers' global competence. Following this, rural science teacher educators share their efforts involving their teacher preparation programs. Finally, the panel leads a discussion on internationalizing rural science teacher preparation.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Science Teachers' Views and Enactment of Culturally and Linguistically Responsive Instruction
4/21/23, 10:45-12:15, Salon A2 (LL)

Examining the Impact of Professional Learning Experiences on Understanding around Diversity, Equity, and Inclusion Principles

Cindy Kern*, Quinnipiac University, USA
Anna Brady*, Quinnipiac University, USA
Carrie DePetris Duell, Lincoln Middle School, USA
Jennifer DePetris Duell, Francis T Maloney High School, USA

ABSTRACT
The complex problems of societal and racial injustices require increasingly innovative approaches: Our three-year grant-funded program seeks to advance diversity in science by supporting contextualized development of college-readiness skills with 100 Students from under-resourced districts. Through a lens of science, Students are supported in authentic sensemaking of community-based phenomena or problems, mentored by science teachers (Facilitators), university students (Mentors), and university Faculty.
Our program's success depends on building authentic community among participants, one potential challenge to which is our own positionality: Faculty and Facilitators, who are > 90% white and middle-aged, will be supporting secondary Students from a wide range of backgrounds. While effective teachers can successfully support all students, we acknowledge that even the most well-intended programs may reinforce damaging systems if there is not critical examination of personal biases, beliefs, and blind spots.

The purpose of this research is to examine the impact of our Professional Learning Experiences (PLEs) on Facilitator, Mentor, and Faculty understanding around Diversity, Equity, and Inclusion (DEI) principles, framed by Social Identity Theory (SIT). Our findings suggest the PLEs successfully supported critical examination of identity, and the interplay between identity, classroom culture and student learning, creating a strong foundation upon which to build our program.

Evaluation of Teacher Designed Integrated STEM Unit For Multilingual Learners after Receiving Professional Development

Stephanie Erickson*, University of Minnesota, USA
Gillian Roehrig, University of Minnesota, USA

ABSTRACT

This study evaluates the quality of teacher-designed integrated science, technology, engineering, and mathematics (STEM) units written after receiving professional development in integrated STEM unit design. This presentation will report on the results of the units' cohesiveness and their alignment to integrated STEM frameworks. Teachers were provided with professional development in integrated STEM unit design and time and structure to write integrated STEM units that are personalized to the local community and cultures of districts, schools, and classrooms. Due to the high percentage of students that are characterized as multilingual (ML) learners in the partner district, teachers will also be asked to provide language support integrated throughout their units. Four units were designed and evaluated for their coherence by visually analyzing conceptual flow diagrams (CFG) (Authors, 2021) and given a score on the STEM Integration Curriculum Assessment (STEM-ICA) (Guzey et al., 2016). Results show a wide range of efficacy in developing coherent units that align with current frameworks in integrated STEM. Due to this range, more research on effective professional development for integrated STEM unit design is needed.

Designing and Validating an Observation Protocol for Responsive Science Instruction

Niki Koukoulidis*, University of Florida, USA
Julie Brown, University of Florida, USA
Mark Pacheco, University of Florida, USA

ABSTRACT

The power of culturally and linguistically responsive instruction (CLRI) for emergent bilingual (EB) learners coupled with a lack of its implementation by their science teachers demonstrates a need for a concrete measure of CLRI elements that demystify the approach. This study describes several phases of the development and validation of the Responsive Science Instruction Observation Protocol (RS-OP). The RS-OP operationalizes six CLRI elements in the context of the nationally funded project in which it was created: attention to language, affirming identities, collaboration, funds of knowledge, multiple modalities, and sociopolitical consciousness. The RS-OP has been designed over multiple iterations based on a review of the literature, guidance from an expert panel and teacher participants, and classroom data. Though the validation process is currently ongoing, outcomes thus far include strong evidence of construct validity, content validity, and reliability from pilot testing of two elements of the RS-

OP, multiple modalities and attention to language. In the larger project, to date, the RS-OP has served as an evaluative tool for researchers and a professional growth tool for science teachers. Thus, this work has implications for teachers' professional learning as well as the RS-OP's use as an instrument to assess CLRI in science classrooms.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Teacher Learning at the Intersections of Science and Technology
4/21/23, 10:45-12:15, Salon A3 (LL)

Teachers Create and Implement Augmented Reality Experiments for Physics Lessons

Mareike Freese*, Goethe University, Germany
Albert Teichrew, Goethe University, Germany
Jan Winkelmann, University of Education, Germany
Roger Erb, Goethe University, Germany
Michael Tremmel, Goethe University, Germany
Mark Ullrich, Goethe University, Germany

ABSTRACT
Understanding and creating physical models are a main part of the scientific way of acquiring knowledge and are embedded in curricula. Yet, these are aspects of science lessons that students and teachers often have difficulties with. Augmented Reality (AR) is a digital tool to superimpose virtual visualizations on real backgrounds. It can help linking models and experiments, which usually are not part of the same lesson. Nevertheless, both pre-service and experienced teachers consider their digital teaching competences insufficient. Within the project presented in the paper, a concept for continuing professional development (CPD) was designed and conducted. It aims at guiding teachers in the use of AR in secondary school practical physics lessons. Furthermore, it promotes their digital media and modeling skills while the teachers actively construct their own AR experiments. The effectiveness of the CPD was evaluated with mixed methods through the development of the teachers' digital competences, modeling competences, and willingness to use digital tools, especially AR, in school.

Building Lessons that Bridge Instructional Practices and Science Innovations

Kimberly Ideus*, NC State University, USA
M. Gail Jones, NC State University, USA
Julianna Nieuwsma, NC State University, USA
Emma Refvem, NC State University, USA
Kathleen Bordewieck, NC State University, USA
Soonhye Park, NC State University, USA

ABSTRACT
This exploratory case study examined factors that influence teacher lesson planning as well as the process that they use to create lesson plans. This is important because it helps science

education researchers understand the process that teachers use when planning lessons after learning new science content. It highlights the factors, content that correlates to standards and curriculum, activities that engage students to want to learn, and real world connections, that influence teachers as they make considerations for their future students. There were five case study participants who completed S-STEM survey, six interviews, and three lesson plans. The results showed that teachers primarily consider standards and curriculum, real world connection, and student engagement when planning a lesson after learning new science content.

Research Practice Partnership: Culturally Responsive Computational Thinking Professional Development

Eleanor Richard*, University of Massachusetts Dartmouth, USA
Shakhnoza Kayumova, University of Massachusetts Dartmouth, USA
Mia Dubosarsky, Worcester Polytechnic Institute, USA
Gillian Smith, Worcester Polytechnic Institute, USA
Tiffany Davis, Ashburnham Westminster Regional Schools Public Schools, USA

ABSTRACT

Although the professional learning opportunities for science teachers to introduce computational thinking (CT) are increasing, it remains challenging to support teachers in integrating CT into their everyday science practices in ways that are culturally responsive. In this study, we examine the outcomes of a research-practice partnership (RPP) which was designed to develop and implement culturally responsive CT professional development; this RPP was co-designed and co-led by local researchers, policymakers, professional development coaches, administrators, and educators in central Massachusetts. We analyzed the lesson plans and written reflections of the 10 teachers participants in a 3-day RPP-led professional development to find emergent patterns as teachers tackle integrating culturally responsive computational thinking into science teaching. The results shed light on some opportunities and challenges of RPPs in designing and developing comprehensive and effective culturally relevant computational thinking professional learning at elementary levels.

Advancing design-based pedagogy using theme of ‘presence' for STEM teachers using robotics

Adam Devitt*, California State University, USA
Moyu Zhang, New York University, USA

ABSTRACT

We embrace the stance that teachers are intellectuals in the teaching profession. We advance our model of professional development as ‘design-partners' and support teacher development of professional expertise in designing innovative curricula and instructional practice integrating LEGO robotics into their teaching practice. In this study we evolve our model of design-based pedagogy to incorporate systemic instruction using ‘presence'. As an interpretive inquiry, we use this new model to analyze one teacher's story of her professional practice as she displays professional knowledge to support student and personal learning of mathematical concepts.

Strand 10: Curriculum and Assessment

SC-Organized Paper Set: Evidence based Instructional strategies to improve student learning

4/21/23, 10:45-12:15, Salon A1 (LL)

Developing Three-Dimensional Instructional Strategies Based on Students' Performance on Classroom Assessments

Peng He*, Michigan State University, USA
Namsoo Shin, Michigan State University, USA
Katy Nilsen, WestEd, USA
Holly Amerman, University of Georgia, USA
Joseph Krajcik*, Michigan State University, USA

ABSTRACT

This study aims to use student performance on classroom assessments to develop three-dimensional (3D) instructional strategies teachers can use to improve student learning. To achieve this goal, we followed a design model to develop four types of 3D instructional strategies to support multiple groups of students with different performance patterns on a 3D assessment task. A panel of six expert teachers was interviewed to provide feedback on improving the instructional strategies. Using qualitative thematic analysis, we found that expert teachers perceived those instructional strategies could support student performance. Moreover, their feedback on goal orientation, feasibility, cultural relevance, and inclusion and fairness are valuable for improving our 3D instructional strategies. The findings of this study will interest NARST members in expanding their knowledge of the design process and the nature of 3D instructional strategies.

Enacting curriculum that are coherent from the student perspective: Exploring the teacher-storyline relationship

Kevin Cherbow*, BSCS, USA
Katherine McNeill, Boston College, USA
Benjamin Lowell, Boston College, USA

ABSTRACT

Realizing science education reform will require substantive changes to science curricula to focus on ‘coherence from the student perspective' in design and enactment. This form of coherence arises when students see their science work as addressing their questions and problems. Storylines offer one approach to support coherence for students because these materials are designed for students to be partners in developing and managing knowledge-building across each unit. While significant attention has rightfully been placed on developing the storyline approach and materials, insufficient attention has been given to understanding teachers' actual use of these storylines to design coherent instruction. We address this gap by providing an initial model of this instructional design work called the Teacher-Storyline relationship. Broadly, this relationship entails the activity in which the teacher interacts with and

uses storyline materials to design instruction with the goal to be coherent for students. This relationship concerns the teacher, the storyline materials, the participatory interactions between the two, and the resulting planned and enacted storyline that is an outgrowth of this relationship. In this article, we explain each component and then discuss the implications of this relationship for the design and use of storyline units.

Analyzing Educative Features in NGSS-aligned Science Curricular Materials

Tania Jarosewich*, Censeo Group, USA
Kevin Hall*, University of Illinois, USA
Barbara Hug*, University of Illinois, USA

ABSTRACT

This study applied to a set of curriculum lessons a framework for analyzing features of science curricular materials that are educative, that is, help teachers build capacity to notice students' ideas and plan and enact NGSS-aligned instruction. We analyzed middle school lessons across research-based, NGSS-aligned units developed by different curriculum development groups. All units were phenomenon-based, building off of students' ideas and practices. The coding framework was based on work conducted in the field of mathematics, and in a previous project applied and extended to NGSS-aligned science instruction. The framework identifies specific features of curricular materials that can promote teacher learning: attending to student thinking, attending to disciplinary ideas or practices, attending to connections across lessons, providing explanations of instructional tools/practices, and providing instructional choices. The initial patterns that we see in the analyzed curricular materials suggests that materials communicate to teachers by directing actions, guiding instructional responses, and attending to content and practice. Our future work will extend this work by applying the coding framework to additional curricular materials to support instructional design and educative capacity of curriculum materials.

Systematic Validation in Science Learning Progression Research

Hui Jin*, Georgia Southern University, USA
Hyo Joeng Shin, Sogang University, Korea, Republic of

ABSTRACT

Learning Progressions (LPs) are cognitive models that describe the development of scientific knowledge and practices in students. Scholars have advocated for using LPs to align curriculum, instruction, and assessment into a coherent system, and by doing so, promote productive learning. Systematic validation can be used to monitor and evaluate how well LPs enhance the coherence in curriculum-instruction-assessment systems. We will present a framework that guides systematic validation in LP research. In the framework, an interpretation/use argument and a validity argument are established to ensure that the LP align curriculum, instruction, and assessment into a coherent system. The interpretation/use argument contains three claims and their assumptions. The three claims are the LP, students' proficiency measured by the LP, and the use of the LP to inform teaching. The validity argument specifies what and how theoretical rationale and empirical evidence are obtained and used to evaluate those assumptions and hence the claims. We use our work on a Mathematical

Thinking in Science (MTS) LP to illustrate how these two arguments. The framework, along with our experiences and lessons learned, will be of value to other researchers as conducting their LP studies.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set: Leveraging the Arts to Center Equity, Justice, and People of Color in Science Education
4/21/23, 10:45-12:15, Blvd C (L2)

Broadening Under-Represented Students' Interest and Participation in Science Through Drama
Maria Kolovou*, University of Miami, USA

ABSTRACT
This study uses case study design embedded in a grounded theory approach to examine how drama may broaden under-represented youth's interest and participation in science. The study initially followed 12 racially and linguistically diverse students enrolled in a STEAM elective at an elementary urban public school (4-6 graders). Data included video records of group activities, 12 semi-structured interviews, ethnographic observations, pre- post-surveys with open-ended and Likert-type questions, and students' daily journal entries. After the initial grounded theory analysis, three cases of African American students were selected for in-depth analysis. Preliminary findings point to drama's potential (a) to support students' agency for appropriating their funds of knowledge and (b) to broaden students' interest due to social justice inquiries it may provoke.

The Arts in a Social-Justice-Centered Middle School Science Class
Stephanie Spezza*, University of Illinois Chicago, USA

ABSTRACT
Schools, and science classes within them, are prone to reproducing the same oppressive structures found in society by valuing forms of discourse and knowledge based on dominant narratives and, therefore, narrowing what is considered science. Arts integration in science education offers a pathway to amplify marginalized voices, and presents opportunities to develop complex and nuanced science identities. For justice centered pedagogies, such possibilities are essential. In this study I focused on art making in my science 6th grade classes (46 students identifying as Latinx, or Black and/or African) that centered social justice science issues, and explored how art making offered my students opportunities for science learning (i.e., knowledge and identity construction). The findings show that students experienced identity and identification tensions while engaging in the art-making process-products for thinking about and representing social justice ideas. Moreover, art offered students a pathway to create and express the intersection of science learning, criticality, and emotion. Thus, negotiating art making and science can become a catalyst and an outlet for students' epistemic affect and their engagement with social justice issues, and a tool for critiquing

master-narratives of science by challenging what it means to "do" science and who gets to "do" it.

Children's Identity Work Within an Embodied Arts-Based Approach to Science Education
Rebecca Kotler*, University of Illinois Chicago, USA
Ronan Rock, University of Illinois Chicago, USA
Maria Varelas, University of Illinois Chicago, USA
Amanda Diaz, University of Illinois Chicago, USA
Hannah Natividad, University of Illinois Chicago, USA
Phillip Bowen, Chicago Public Schools, USA
Rachelle Tsachor, University of Illinois Chicago, USA
Nathan Phillips, University of Illinois Chicago, USA
Rebecca Woodard, University of Illinois Chicago, USA
Jaegen Ellison, University of Illinois Chicago, USA

ABSTRACT
Science education often ignores children's multiple identities and ways of being in the world. Embodying science through performing arts practices invites children's multiple identities to intermingle, creating expansive engagement and contesting historical and political conceptions of recognition in science. Through a case study design, we explored science identity work of children with minoritized ethnoracial identities, as they collaboratively planned, performed, and reflected on their own and others' science enactments in their 5th-6th grade classrooms. Identity manifestations were analyzed to capture identities-in-practice and identities-in-narratives. Three themes emerged about children's narrated and performed identities: (a) children perceived a bi-directional relationship of competence in science and in embodied communication-performing; (b) children viewed commitment to both acting out science and expanding science knowledge as important indicators of one's own and others' positioning in science; and (c) children perceived and embraced collectivity of learning when engaged in performing-arts-infused science. The study illuminates the ways in which embodied construction and communication of science knowledge and identities mitigate children's and people's limited meanings of who and what gets positioned as scientific, and bring attention to the power of the performing arts in constructing and communicating science ideas among performers and audiences.

Embodying Physics: Exploring the power of dance as a resource for physics learning and engagement
Folashade Solomon*, TERC, USA
Dionne Champion, University of Florida, USA

ABSTRACT
Physics is often presented and framed in ways that are disembodied and acultural, separating learners from opportunities to utilize their bodies and kinesthetic experiences as sense-making resources (Prescod-Weinstein, 2021). In this presentation, we share findings from a qualitative research study that is examining the situated, embodied cultural practices of Black girls in an embodied physics learning environment, where participants are asked to explore physics

concepts through creative expressive movement and dance activities. Our findings show that embodied exploration of physics concepts (e.g., including Newton's Laws, gravity, wave behaviors, and atomic elements) through dance supported sustained engagement, invited youth to engage in inquiry using multiple movement vocabularies, and offered participants opportunities to connect personally and culturally to physics concepts and ideas. This work provides a window into the range of resources available for physics exploration and illuminates possibilities for culturally relevant physics pedagogies. Understanding the value of dance as a resource for scientific engagement can have a critical impact on how we think about physics teaching and learning.

Ethnodances of Black Students' Science Identity Authoring as Windows into their Science Experiencing

Mindy Chappell*, Portland State University, USA

ABSTRACT
This study examined how students used ethnodance to author and narrate their experiences in science spaces and convey the affective and emotional dimensions of their experiences. As five Black high school students with developed dancer identities used what I have named 'ethnodance' to author and narrate their evolving science identities, I looked for ways in which their dances conveyed the emotions, tensions, trials, and tribulations associated with their experiences. I present an empirical illustration of how students' ethnodances and reflections portray how they saw themselves and the emotionality of their experiences in science spaces. Building on the consideration that for students whom a meaningful part of social life includes movement and dance in/outside of school, the theoretical argument frames ethnodance as an embodied narrative, dance as a form of cultural expression and social life for some Black youth, and identities-in-narratives as a window into students' agentic power to disrupt normative science ideologies and carve a place for themselves in science. Furthermore, students' ethnodances offered them opportunities to transduce the affective and emotional dimensions of their experiences, construct who they were becoming as science people, and story their science identities in ways that their written narrations could not represent.

Strand 12: Technology for Teaching, Learning, and Research
SC-Organized Paper Set: Artificial Intelligence and Machine Learning in Science Education
4/21/23, 10:45-12:15, Salon C7-8 (LL)

Using Machine Learning for a qualitative evaluation of Concept Maps: New opportunities for formative assessment?

Tom Bleckmann*, Leibniz University Hannover – Institute for Didactics of Mathematics and Physics, Germany
Gunnar Friege, Leibniz University Hannover – Institute for Didactics of Mathematics and Physics, Germany
Wolfgang Gritz, L3S Research Center, Leibniz University Hannover, Germany

ABSTRACT
Formative assessment has long been considered as one of the best ways to optimize school learning. Concept maps are known as good tools for formative assessment. They are directed graphs in which the nodes represent well-defined concepts and the edges their relationships. Qualitative analysis of concept maps often cannot be integrated into daily school routine due to time limitations. This means that there is still a lot of potential and wide variety of information in concept maps that can be used to improve education. The goal of this paper is to provide a first step towards an automatic qualitative evaluation of concept maps with the use of Machine Learning techniques. For this purpose, a concept map on the topic of mechanics was developed and completed by 203 students. The students were asked to identify 19 relationships between 11 given concepts. Afterwards, these relationships were rated by two different raters using a four-point scale. For the automatic qualitative evaluation, a separate text classification model was developed for each relationship. Results show good agreements between human ratings and ratings generated by Machine Learning. The use of Machine Learning can therefore push science educational research further and encourage the development of automated feedback.

Rethinking Science Education through Applications of Artificial Intelligence: Unpacking Ethical and Societal Aspects

Selin Akgun*, Michigan State University, USA
Joseph Krajcik, Michigan State University, USA

ABSTRACT
Artificial intelligence (AI) embodies the applications of machine learning, and natural language processing through intelligent tutoring, automated assessment, and facial recognition systems. Without a doubt, applications of AI are useful to both teachers and students, especially during and the aftermath of the COVID pandemic. They potentially help teachers to lessen their workload and capacity, and support students' cognitive and social development. However, AI applications also pose critical ethical challenges in K-12 education settings. Integration of these algorithms in education may perpetuate societies' existing systemic biases, amplify privacy, surveillance, and autonomy issues for students from marginalized and underserved groups. Here, we introduce various applications of AI in K-12 science education, focusing on their affordances and drawbacks. Then, we introduce existing and growing instructional materials to help educators navigate the challenges of integrating AI, and advance students' understanding of AI and ethics, and make connections between how AI, ethics and science education is closely connected to each other. The paper concludes with future recommendations for research.

Teacher Acceptance of Artificial Intelligence Technologies for Teaching and Learning: A Systematic Review

Holly Amermanm*, University of Georgia, USA
Xiaoming Zhai, University of Georgia, USA

ABSTRACT
Artificial Intelligence for Education (AIED) has been proposed to solve many educational problems, including differentiation, instruction of students with disabilities and emerging bilinguals, and the alleviation of burdensome teacher tasks to allow teachers more time to work with students. AIED promises to address students' three-dimensional reasoning about science topics for science educators, as recommended by the Framework for K-12 Education (NRC, 2012) through formative assessment, intelligent tutors, and interactive and inquiry-based online explorations (Zafari et al., 2022). Few studies have examined teacher acceptance of AIED, a factor that is the most critical to the use of educational technologies (Scherer and Teo 2019). An extensive literature search revealed only 16 empirical studies of teacher acceptance of AIED published between 2014-2022. Using the framing introduced by Nazaretsky et al. (2022) of eight specific features unique to AIED- preferred methods to increase trust, lack of transparency, perceived benefits, self-efficacy, anxiety, human dislikeness, human advice vs. AI advice, and perceived changes in pedagogy, this work examines what has been discovered about teacher acceptance of AIED and makes recommendations on what steps should be taken next.

Computational Model of Teacher Adaptive Expertise in the Development of Epistemic Tools

Richard Lamb*, East Carolina University, USA
Brian Hand, University of Iowa, USA
Jee Kyung Suh, University of Alabama, USA
Gavin Fulmer, University of Iowa, USA

ABSTRACT
Teacher epistemic practices or epistemic tool use involves the use of tools such as dialogue, argumentation, and science language has been used to help elementary teachers create generative learning environments (GLE) in the science classroom. The purpose of this study is to computationally model and capture the impact of teacher adaptive expertise related to epistemic orientation across seven factors thought to produce generative learning environments. A computational model is mathematical model designed to study, predict, and simulate complex systems not otherwise readily accessible due to their complexity. Typically, these models are dynamic real-time continuous models requiring extensive computational power. Data used for the computational model was secondary data taken from two-year study of epistemic tool use and epistemic shifts in teacher practices. The authors of this computational study use a generalized Bayesian Network in the form of a machine learning artificial neural network (ANN) as the foundation of the model of shift in epistemic orientation. Results of the computational experiment to classify the probability of GLE adoption provide a window into the underlying processes. The findings of this study that during development of epistemic orientations toward GLEs that adaptive expertise appears to be critical in promoting teachers' epistemic shifts.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set: Promoting students' interest in sustainability
4/21/23, 10:45-12:15, Salon A4 (LL)

Promoting Public Concern Towards Unpopular Endangered Species: Studying the Impact of In-Situ Mediated Shark Observation

Nurit Carmi*, Tel-Hai Academic College, Israel

ABSTRACT

One of the challenges for bio-diversity conservation is the fact that there are many endangered species that are not popular, but whose conservation is, nonetheless, important. The present study deals with sharks who suffer from demonization and, accordingly, from public indifference to the deteriorating state of their conservation. We used the seasonal appearance of sharks in the Israeli coastal zone to study public perceptions and attitudes towards sharks prior to ("control group") and after ("visitors") shark watching during a visit in on. We found that the shark's image was significantly more positive among the visitors compared to the control group. We also found that visiting the information center was strongly related to a more positive shark image and more positive attitudes toward shark conservation and willingness to act to preserve them.

A Moral Framework for Using Animals in Education: Making Difficult Socioscientific Decisions More Systematic

Bryan Nichols*, Florida Atlantic University, USA

ABSTRACT

Cognitive science and neuroimaging are rapidly improving our knowledge of how other animals think and feel, and science learners are taking notice. This presentation addresses the importance of more systematic moral consideration of how we portray and use animals in science education, including direct interactions such as dissections, wildlife study, and class "pets", as well as indirect consideration such as the examples, stories, and media we use to portray animals in learning. It introduces a framework based on common morality, a tool that makes difficult decisions more systematic by breaking them down into steps. The framework relates to socioscientific reasoning, including expanding perspective taking across species, and makes clear that if we use common educational justifications for harms to animals then we must carefully consider indirect or unintended learning and always incorporate effective assessment. The framework guides decision making into whether an action is moral or immoral; session participants will get a chance to consider the tool in various science education scenarios and provide input to adapt or refine it for local contexts and cultures.

Measuring Rural High School Students' Beliefs about the Bioeconomy and Career Interests

Katherine McCance*, North Carolina State University, USA
Karen Collier, North Carolina State University, USA
Margaret Blanchard, North Carolina State University, USA

Richard Venditti, North Carolina State University, USA

ABSTRACT
Diverse representation is important in the STEM workforce. However, White men are disproportionately employed, especially in the bioeconomy. To achieve workforce, sustainability, and diversity/equity goals, promoting K-12 students' knowledge and awareness of the bioeconomy is important, especially in rural communities. Two instruments were validated in this study to measure high school students' beliefs about bioproducts/bioenergy (BABB) and career interests in bioproducts/bioenergy fields (CIBB), focusing on students in rural, high-needs schools, and using an Expectancy Value Theory task value lens. Confirmatory Factor Analysis and internal reliability analyses were conducted. The BABB (N = 127) had two related subscales, Personal (BABB-P) and Societal (BABB-S), each consisting of eight items. The one-factor CIBB (N = 106) had four items. Nonparametric analyses were performed to identify differences in BABB and CIBB scores based on demographic characteristics. Analyses of individual survey items revealed that students from historically underrepresented racial groups and female students tended to have more positive beliefs and career interests. These results suggest an important connection between students' values and their interest in bioproducts/bioenergy and related careers. They also point to the potential of recruiting interested students from historically underrepresented groups and diversifying the bioeconomy.

Building Students' Understanding of Natural Hazards and Confidence to Engage in Community Resilience Efforts

Megan Littrell*, CIRES Education & Outreach, USA
Kathryn Boyd, CIRES Education & Outreach, USA
Katya Schloesser, CIRES Education & Outreach, USA
Alica Christensen, CIRES Education & Outreach, USA
Anne Gold, CIRES Education & Outreach, USA
Irfanul Alam, CIRES Education & Outreach, USA
Casey Marsh, CIRES Education & Outreach, USA

ABSTRACT
The HRC curriculum aims to empower youth and build their agency to understand and improve community resilience to natural hazards through a place-based curriculum, grounded in Sociocultural Learning Theory. The curriculum aligns with NGSS standards for middle and high school students around natural hazards and encourages students to partner with local experts and resilience practitioners, with the goal of inspiring action and hope, building social cohesion, and support for local resilience planning, as outlined in the NOAA Community Resilience Education Theory of Change. The current study examined the impacts of this approach on students in terms of their awareness, learning, and in what ways the unit inspired or empowered them to engage in local community resilience efforts. The findings of the current study, from both students' responses and teachers' reflections on the impacts on their students, suggest this approach improved students' a) knowledge about natural hazards preparation and response in their communities; b) understanding of community resilience; and c) confidence in talking to community members about resilience strategies. The study is an

important contribution to the emerging field of resilience education, studying a variety of instructional methodologies and strategies.

Strand 15: Policy, Reform, and Program Evaluation
SC-Organized Paper Set: Equity and Community
4/21/23, 10:45-12:15, Blvd A (L2)

What is "Community Level" Scientific Literacy? A Systematic Literature Review and Delphi Method Study

K.C. Busch*, North Carolina State University, USA
Aparajita Rajwade*, North Carolina State University, USA

ABSTRACT
While scientific literacy has been widely held as a desired outcome of science learning within formal and informal settings, it has generally only been considered at the individual level. However, large-scale collective issues—such as climate change or pandemics—has illustrated that individual scientific literacy is insufficient for meaningful solutions. Instead, scientific literacy is needed at the "community level." In this session, we present the results of a systematic literature review and a Delphi method survey study of experts to identify how community level scientific literacy may be conceptualized, offering a foundation for further research.

Why did it work? Using the Most Significant Change Method to Understand a Science Partnership

Maia Elkana*, Washington University in St. Louis, USA
Rachel Ruggirello*, Washington University in St. Louis, USA
Alison Brockhouse, Washington University in St. Louis, USA

ABSTRACT
This study investigates the impact of a Next Generation Science Standards-designed curriculum program within a research-practice partnership aimed at removing barriers to high-quality science instruction in a large urban public school setting. This paper seeks to learn more about how this program functioned in a new context using the Most Significant Change (MSC) method, while also interrogating the utility of qualitative methods for rigorously evaluating the impacts of the partnership effort in the absence of student assessment data. Science educational initiatives can be difficult to evaluate and student outcomes can lag years behind the implementation. Educator interviews were conducted using the MSC technique and 27 stories were compiled and collaboratively analyzed. The analysis revealed seven domains of change across two years, and stakeholders voted on the most significant stories, some of which aligned to the goals of the program, while others were unexpected. Stakeholders used this data to update the theory of change and modify program design. Overall, this study suggests that qualitative evaluation methods, such as the MSC, can uncover context-specific

nuance and support the development and refinement of a theory of change to support program design for science curriculum and professional development efforts.

Equity-Focused Computer Science Education: An Analysis of State Policy Infrastructures Designed to Achieve Equity

Stefanie Marshall*, University of Minnesota, USA
Ain Grooms*, University of Wisconsin, USA
Joshua Childs, University of Texas- Austin, USA

ABSTRACT
In this interdisciplinary comparative case study, we examine how states have created a policy infrastructure to support the implementation of equity-focused computer science education (CSEd). This study specifically examines the CSEd infrastructures of states that have expressed a dedication to equity in state-level computing education reforms. Our study draws on qualitative research methods and social network analysis to understand policy infrastructures and the related challenges and promises as states continue to advance equity. Data from an electronic survey, a social network survey, individual interviews with CSEd stakeholders, and policy documents (e.g., state policies, reports, etc.) will be collected and analyzed. Findings can inform equity-focused CSEd reform efforts—specifically to meet the needs of marginalized youth and support equitable CSEd within and between states.

Perspectives on heterogeneity in the context of vocational education and training

Simone Rueckert*, University of Duisburg-Essen, Germany
Helena van Vorst, University of Duisburg-Essen, Germany

ABSTRACT
In its wide definition, inclusion epitomizes that each learner matters equally and should not be excluded from education regardless of gender, ethnic or social origin, language, special educational need (SEN) and many others. German vocational schools cater for a large and diverse group of students. A rising number of students with a migration background within the last years, demographic change and the lack of skilled workers pose significant and ongoing challenges for the vocational sector (Euler & Severing, 2014; IT NRW, 2020). Therefore, it is crucial to integrate as many young people as possible into the regular labor market and to open the education system toward absolute accessibility (Heinrichs & Reinke, 2019). To gain insights into in-service teachers' and students' minds at vocational schools concerning inclusive teaching and learning, we applied a mixed-methods design with a questionnaire for students (N=162) and an open-question-survey for teachers (N=17). Through Grounded Theory Methodology we were able to distinguish conditions and support needs of teachers at vocational schools, whereas the student questionnaires revealed how some impairments influence students' perception of lessons.

Concurrent Session 13
4/21/23, 13:45-15:15

Strand 1: Science Learning: Development of student understanding
SC-Organized Paper Set: Ontology and Epistemology in Science Classrooms
4/21/23, 13:45-15:15, Salon C7-8 (LL)

"Complex is useful": the epistemology of physics of complex systems as scaffolding for identity development

Francesco De Zuani Cassina*, University of Bologna, Italy
Olivia Levrini, University of Bologna, Italy

ABSTRACT
Science education research has been paying great attention to disciplinary identity to address issues like accessibility, persistence, agency, relevance, equity, social justice, discrimination in the STEM field. Most of the studies analyze identity from socio-cultural perspectives, conceiving disciplinary identity as a positioning of the self within communities of practice.
In our study, an epistemological perspective was taken to elaborate on the construct of "physics epistemic identity", that dimension of personal identity which the epistemic core of physics can contribute to forming. We selected a database comprised of 6 essays, written by 6 groups of 4 students each during an extracurricular course of "story-telling", held in a secondary school (grade 9). In the course, the basic concepts of the physics of complex systems were introduced as thematic constraints for the story.
Basing on the Family Resemblance Approach to NOS elaborated by Erduran & Dagher (2014), an analytic tool (coding system) has been developed to recognize, in the data, themes related to the epistemic core of physics, themes related to personal identity and their eventual relations. The analysis shows that it is possible to investigate if and how the epistemic disciplinary core of physics can act as scaffolding for personal primary questions.

Gesture Complements Language as a Window onto Novices and Experts' Ontological Categorization of Scientific Concepts

Mariam Yamout*, University of Calgary, Canada
Tamer Amin, American University of Beirut, Lebanon

ABSTRACT
This study addresses the debate in the conceptual change literature on the role of ontology in the learning of science concepts between proponents of the Ontological Shift (OS) and Dynamic Ontologies (DO) views. Proponents of both views have used language analysis as a window onto ontological categorization. We ask what systematic gesture analysis alongside language can reveal about learners and experts' ontological categorization of science concepts. This study is, in part, a replication of Slotta et al. (1995). Novices and science experts solved problems dealing with concepts of heat, light and electric current as well as isomorphic material substance problems. Gestures were added as an analytical lens onto novice and expert ontological categorizations across problems. The systematic gesture

analysis revealed a global pattern of change where experts used both material substance and interaction-based process ontological conceptualizations while novices relied exclusively on material substance predications. Additionally, experts' use of material substance conceptualizations was embedded in their process conceptualizations. We further note variation in the production of inconsistent and consistent pairs across novices and experts. Thus, such findings suggest that elements of both OS and DO views are correct. We further discuss the instructional implications that builds on aspects of both views.

Epistemic Dispositions in Socioscientific Issues-Based Systems Modeling

Jamie Elsner*, University of North Carolina at Chapel Hill, USA
Eric Kirk, University of North Carolina at Chapel Hill, USA
Li Ke, University of Nevada Reno, USA
Troy Sadler, University of North Carolina at Chapel Hill, USA

ABSTRACT
This study explores students' use of epistemic practices during a socioscientific issues-based modeling task. Socioscientific issues are ill-structured problems of society that can be explained using scientific reasoning. In this activity, pairs of students work together to construct a systems model of COVID-19 using examples from their everyday lives. We analyze student discourse to determine which epistemic operations were performed by students as they made sense of the complex issue. We found that students engage in the epistemic practices of proposing knowledge, evaluating knowledge, and legitimizing knowledge with proposing knowledge being the most frequently used. Students also demonstrated an understanding of complex interactions within the system, moral implications of different factors, and the value of other positions. Moreover, students designed their systems models to reflect different dimensions of the socioscientific issue (e.g., politics, economics, ethics, health) and considered the problem from multiple perspectives. This is a significant finding because we want students to be able to integrate multiple lines of reasoning as they develop holistic arguments in response to socioscientific issues. Systems modeling in the context of socioscientific issues is a valuable approach to promote student engagement with epistemic practices and support systems thinking.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Symposium: 10 years on: Rethinking NGSS's Underlying Principles from Ethical and Posthuman Perspectives
4/21/23, 13:45-15:15, Salon A5 (LL)

10 years on: Rethinking NGSS's Underlying Principles from Ethical and Posthuman Perspectives

Catherine Milne*, New York University, USA
Kathryn Scantlebury*, University of Delaware, USA
John Lupinacci, Washington State University, USA
Marc Higgins, University of Alberta, Canada

Anna Skorupa*, New York University, USA
Shakhnoza Kayumova, University of Massachusetts, USA
Jesse Bazzul, University of Regina, Canada
Sophia Jeong*, Ohio State University, USA
Elena Silverman, Indiana University, USA
Nickie Coomer, Colorado College, USA
Rouhollah Aghasaleh, California State Polytechnic University, USA
Jenny Tilsen, University of Minnesota, USA
Matthew Weinstein, University of Washington, USA

ABSTRACT
In this symposium the authors explore how new materialisms including feminist materialism, new materialism, neomaterialism, and posthumanism provide inclusive ways of rethinking the science that underpins the Next Generation Science Standards by foregrounding material and epistemic practices which are interdependent. The authors invite participants to imagine a science freed from a Cartesian worldview which posits a world composed of independent participants with essential characteristics and instead focus on a science that begins with relations. The authors invite participants to imagine a science and education that is not based on binaries such as human/phenomena, subject/object and where humans are not placed at the center. This symposium provides space to engage with alternative approaches to thinking about science teaching and learning that argue for the entanglement of reality and knowing in contrast to a world of binaries, in so doing providing alternative ethical positioning for producing truths for a world in which culture and nature are entangled. Rather than working an idealized reality from which humans are removed or which is in their heads science education has a responsibility to take entanglement with the material world seriously because, without that, our empirical accounts will always be inaccurate and underdone.

Strand 3: Science Teaching - Primary School (Grades preK-6): Characteristics and Strategies
SC-Organized Paper Set: Language and Elementary Science Teaching
4/21/23, 13:45-15:15, Blvd A (L2)

Examining Elementary Teachers' Reflections on Their Ability to Facilitate Argumentation-Focused Discussions in a Simulated Classroom
Jamie Mikeska*, ETS, USA
Pamela Lottero-Perdue, Towson University, USA
Devon Kinsey, ETS, USA

ABSTRACT
The study's purpose was to explore the nature of in-service elementary teachers' self-reflections from video records of them facilitating argumentation-focused discussions with five student avatars in an online simulated classroom. This examination included exploring the types and nature of the evidence they drew on to support their assertions about the quality of

their discussion facilitation linked to five dimensions of this instructional practice. Findings suggest that most teachers' reflections on their discussion practice tended to be positive in nature, with limited instances of them mentioning areas for potential improvement. In addition, findings suggest that most in-service teachers used multiple pieces of evidence to justify their overall quality assessment of each discussion aspect. Furthermore, the types of evidence they used were aligned with the rubric used by raters to provide feedback on the teacher's performance but varied in nature across the participating in-service teachers. Finally, findings show that study participants tended to draw upon what students said and did during these discussions as evidence to support their overall assertions about how well they attended to specific discussion aspects. Implications for using videos from online simulated teaching experiences as tools for teacher reflection are discussed.

Science Discourse Patterns Compared with Instructional Practices During a Maker Activity in an Elementary Classroom

Tyler Hansen*, Utah State University, USA
Colby Tofel-Grehl, Utah State University, USA

ABSTRACT

While minimal instruction has limited evidence as an effective instructional strategy for learning discrete content knowledge and skills, other aspects of its value have not been explored, particularly as related to classroom discourse. Here, we conduct a cross-case analysis of direct instruction and minimal instruction and examine the affordances of each instructional model as pertaining to science discourse. Contextualized within a Maker based curriculum deployed in two semi-rural elementary classrooms, we coded discourse from about 20 hours of classroom instruction and work time. Findings indicate that minimal instruction yields much more discourse in general and a great deal more student questioning when compared with direct instruction. While more direct instructional styles may have better learning outcomes for skill acquisition, it may actually limit students' discursive decisions within the classroom.

Integrating Science and Language for Multilingual Learners: Results of a Two-Year Professional Development Collaboration

David Crowther*, University of Nevada, Reno, USA

ABSTRACT

This session will report on a two-year qualitative case study focusing on a university and school partnership in a rural PK-4th elementary school on teacher experiences in integrating NGSS-based three-dimensional teaching aligning with the Next Generation Science Standards (NGSS Lead States, 2013) and the district-wide adopted Full Option Science System (FOSS) science curriculum. The research variable introduced in the professional development utilized the FOSS curricular model to integrate the WIDA Language Practices (Molle & Wilfrid, 2021), the WIDA Framework for Equitable Instruction (Molle & Wilfrid, 2021), and Discourse Moves (including student to student and teacher to student discourse strategies) developed in the Doing and Talking Math and Science, a NSF funded and WIDA-supported project (http://stem4els.wceruw.org/resources.html) to enhance lesson instruction for Multilingual Learners (MLs). Using a qualitative Case Study design (Stake, 2005), research was collected from

interviews, focus groups and teacher observations over a two year period. Data was analyzed using the constant comparative method to answer the research question regarding the experiences of teachers as they innovate their science instruction to better engage Multilingual Learners (MLs) in their classrooms.

Supporting Language in Science through Encouraging Teacher Criticality
Emily Reigh*, University of California, Berkeley, USA
Emily Miller, University of Georgia, USA
Maria Simani*, University of California, Riverside, USA
Ayça Fackler*, University of Georga, USA

ABSTRACT
Teachers who work with multilingual learners in science classes are often provided tools, strategies, and structures to employ in their classroom. These tools often supply students with the language they are assumed to lack, which subverts students' opportunities to draw from their own language resources for meaning-making. This two year design-based research study seeks to understand how to engage elementary teachers' criticality in professional learning about language and science, so that they can evaluate when language supports are and are not working for their students. We analyzed video of professional learning, teacher artifacts, and our own analytic memos to determine how criticality becomes salient. We present three shifts in our design constructs to support teachers' criticality, including drawing on teachers' existing, embodied instructional practice. We suggest that criticality is a worthwhile outcome for professional learning, particularly for teachers who are working to support multilingual learners in science.

Strand 5: College Science Teaching and Learning (Grades 13-20)
SC-Organized Paper Set: Special Topics in Physics Education Research
4/21/23, 13:45-15:15, PDR 2 (L3)

Building Pathways to Undergraduate STEM Success: Supporting Science Identity, Research, and Community for Minoritzed Students
Brit Toven-Lindsey*, University of California Los Angeles, USA
London Williams, University of California Los Angeles, USA
Casey Shapiro*, University of California Los Angeles, USA
Denise Ortiz, University of California Los Angeles, USA
Marc Levis-Fitzgerald*, University of California Los Angeles, USA
Tracy Johnson, University of California Los Angeles, USA

ABSTRACT
Developing science identity, or seeing yourself as a scientist, is an important component of science degree persistence and a commitment to pursuing a career in STEM, and can be particularly important for students from racially minoritized groups to help combat the biases and microaggressions they encounter during college. Participating in a well-structured research

program can support retention of minoritized students in STEM and has been shown to help increase science identity and sense of belonging through components such as academic support, faculty mentoring, and early exposure to research. This study focuses on an academic support program for students from minoritized backgrounds that provides early access to rigorous course-based lab research, mentorship, and peer community building. Longitudinal mixed methods data analysis indicates that students in the program increased their science identity during the first year research course, completed science degrees and went on to participate in other research experiences during college at higher rates than a matched comparison group, and felt a strong sense of community with their peers and mentors in the program that bolstered their science identity and sense of belonging on campus. Implications for research and practice are discussed.

Teaching novices expert strategies – Evaluation of a physics course concept

Katja Plicht*, Ruhr West University of Applied Sciences, Germany
Hendrik Härtig, University of Duisburg-Essen, Germany
Alexandra Dorschu, Ruhr West University of Applied Sciences, Germany

ABSTRACT

Since the research on experts and novices holds a lot of information about what makes a good problem solver, it is evident to try to teach those strategies to novices (Ericsson, 2018). The method of worked examples already provides a well-established approach to improve the problem skills, especially for novices (Wittwer & Renkl, 2010). Nevertheless, the formed problem schemes are more likely to support near-transfer problems than far-transfer problems (Atkinson et al., 2003), which makes them less flexible and therefore inferior to those of an expert. Even though the approach cannot be to teach novices to become experts right away, there is still room to develop concepts that take this aspect into account.
In this study, a strategy training is developed to teach physics problem schemes explicitly. To evaluate the concept, the learning gains are compared to a classical tutorial seminar that focuses on the explanation of problem solutions. The implementation is realized in a first-semester physics course for mechanical engineering students. This paper presents both the structure of the implemented strategy training as well as its evaluation. Thereby it can be shown that declarative knowledge about problem schemes benefits with a major effect from the developed concept.

Modeling and Measuring Visual Attention and Learning in an Online Instructional Module in Physics

Razan Hamed*, Purdue University, USA
Yifeng Huang, Stony Brook University, USA
Lester Loschky, Kansas State University, USA
Minh Nguyen, Stony Brook University, USA
N. Sanjay Rebello, Purdue University, USA

ABSTRACT

Computer-Assisted Instruction (CAI) will remain ubiquitous in the post COVID-19 world. Learning using CAI demands a high level of attention given the tendency to be distracted and

mind-wander. How does the online STEM instructor know when learners are having attentional problems and the extent to which these problems affect learning? In the present study we probed the visual attentional and cognitive state of physics graduate students while they went through a multimedia instructional module to refresh their knowledge of Newton's II Law. We integrated data from an eye tracker, webcam, egocentric glasses, screen recording, and mouse and keyboard events to record learners' attention overt attention to the learning environment (+/-) and thinking about learning content (+/-) to analyze students' attention spans during learning from this module. We found that while on average learners were on-task and on-screen for a vast majority of time, we also found evidence of mind wandering. The learning module improved the participants efficiency with which they answered the questions correctly on a post-test relative to the pre-test. Further, we found a positive albeit statistically non-significant correlation between the improvement from pre- to post-test efficiency and the time spent on-screen and on-task during the module.

Characterizing student thinking and evidence-based reasoning during an engineering design activity in introductory physics

Ravishankar Chatta Subramaniam*, Purdue University, USA
Amir Bralin, Purdue University, USA
Jason Morphew, Purdue University, USA
Carina Rebello, Toronto Metropolitan University, Canada
N. Sanjay Rebello, Purdue University, USA

ABSTRACT
Skills needed to solve complex problems are critical for scientists and engineers in the 21st century workforce. Preparing the next generation of STEM workforce and a STEM literate citizenry resides upon the pedagogical innovations that post-secondary students experience in science classrooms. Reform documents and research suggest that integrating engineering design (ED) experiences have the potential to bring value to a science course. We explore such a curricular and pedagogical intervention in which introductory physics labs were modified to incorporate ED. We investigated the ways students articulated their thinking and engaged in evidence-based reasoning as they described their approach to an ED challenge in the lab. We investigated emergent themes and patterns based on a summative exam performance. Four types of thinking and five kinds of evidence-based reasoning emerged in our coding schema from group discussions. High scoring groups on a summative exam tended to utilize a wide range of types of evidence and more often engaged in science concepts and engineering design thinking compared to low scoring groups. Results of this study have implications on how to design and facilitate integrated STEM curricula to foster evidence-based reasoning, and facilitate engagement in different types of thinking and address the "design-science gap".

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Types of talk: insights into the role of Discourse and Talk in science teacher preparation
4/21/23, 13:45-15:15, Salon A2 (LL)

Identifying the characteristics hybrid discourse in undergraduate courses for pre-service science teachers

Hadeel Edrees Dabbah*, Ben Gurion university, Israel
Orit Ben Zvi Assaraf, Ben Gurion university, Israel

ABSTRACT
Hybrid discourse, combining scientific discourse with knowledge and discourse from students' daily lives, is an important strategy in supporting meaningful science learning. Many science teachers, however, have difficulty employing it in their classrooms. To successfully implement hybrid discourse strategies, teachers must receive preparation while training as preservice science teachers. The study presented here examined the creation of the hybrid discourse in undergraduate science courses for pre-service science teachers in a teachers' college in Israel's Arab sector. A linguistic ethnographic method was used to explore the characteristics of such discourse, identifying the resources expressed in the lectures, who used them and when, and how they were used. The exemplar case presented here shows how scientific and local popular culture knowledge are brought together in class by the lecturer, allowing the students to acquire scientific knowledge experientially, and making the science relevant to them. Our study argues for the incorporation of such strategies into preservice professional development, demonstrating the importance of hybrid discourse, the potential contribution of detecting and examining it, and the feasibility of doing so.

Analyzing Discourse Moves Utilized by Preservice Teachers During Enactments of Discussions for Different Epistemic Purposes

Ron Gray*, Northern Arizona University, USA

ABSTRACT
The goal of this study is to examine the ways in which secondary preservice science teachers (PSTs) draw upon specific discourse moves for the purpose of enacting high leverage practices (HLPs) as they facilitate a series of discussions designed for different epistemic purposes. These include discussions for the purposes of 1) activating and eliciting students' ideas about a science phenomenon (eliciting); 2) helping students make sense of new observations, information, or data (sensemaking); and 3) pressing students for evidence-based explanations (pressing). The research question was: Which discourse moves and HLPs were PSTs drawing upon as they enacted discussions for different epistemic purposes and in what ways? The findings indicate significant use of a small number of discourse moves and HLPs. Others likely to indicate more complex group sensemaking were less utilized. These results provide useful starting places for secondary science teachers as they seek to move to more complex forms of discussions for their PSTs.

Concurrent Session 13, 4/21/23, 13:45-15:15

Using the ORID Method to Facilitate Critical Discussions in Science TeacherEducation
Rachel Garcia*, Ohio University, USA
Danielle Dani, Ohio University, USA

ABSTRACT
To promote science teacher candidate's cultural competence and engage them in critical discussion of culturally relevant science pedagogy we developed a structured discussion activity using the ORID Method (Observation, Reflection, Interpretation, Decision). ORID facilitates a learning process that ascends from concrete to abstract reasoning allowing for uncomfortable emotions to be expressed without derailing the process of interpretation and analysis. We modeled the Observation and Reflection portions of the discussion from activities used in a college chemistry class. The interpretation portion reflected models of concepts we wanted students to grapple with as they made decisions about practices they would implement when they teach science. As indicated in the literature, our implementation was constrained by time and class size. However, we found that ORID facilitated participation and engagement by all students and allowed them to articulate key ideas productively. We found the method was effective and expect to refine our models and further develop new topics for discussion using the ORID method.

Strand 7: Pre-service Science Teacher Education
SC-Organized Paper Set: Research investigating self-efficacy in preparing STEM teachers
4/21/23, 13:45-15:15, Salon A3 (LL)

Exploring Elementary Pre-service Teachers' Science and Engineering Teaching Efficacy Beliefs
Christine Pavlovich*, Montana State University, USA
Rebekah Hammack*, Montana State University, USA
Ibrahim Yeter, Nanyang Technical University, Singapore

ABSTRACT
Teacher efficacy is one of the most influential components for effective instruction, highlighting the importance of providing preservice teachers (PSTs) with opportunities to learn how to teach engineering during their college preparatory coursework. Making space for engineering instruction within science methods coursework could provide opportunities for PSTs to enhance their engineering teaching efficacy but also requires course instructors to give up some of the time previously devoted to science-focused instruction. The purpose of this study was to explore how infusing engineering learning opportunities into a science methods course impacts PSTs' science and engineering teaching efficacy and outcome expectancy. Pre/post surveys were completed by PSTs enrolled in a K-8 science methods course offered in four modalities. The course offered multiple engineering-focused learning activities and vicarious source efficacy experiences. Paired samples t-test investigated effects of the course of teaching efficacy and outcome expectancy. MANOVA investigated differences between demographic groups and course modality. PSTs' science and engineering teaching efficacy

beliefs and science and engineering outcome expectancy all significantly increased from pre- to post-test. There was no significant difference between gains based of gender, ethnicity, or course modality.

Investigating Preservice Elementary Teachers Integrated STEM Teaching Self-efficacy

Deepika Menon*, University of Nebraska-Lincoln, USA
Deef Al Shorman*, University of Nebraska-Lincoln, USA

ABSTRACT
This mixed-methods research aims to investigate preservice elementary teachers' (N = 58) integrated STEM teaching self-efficacy during their participation in a STEM semester at a large Midwestern public university. The following questions guided the research: (1) How does preservice elementary teachers' integrated STEM teaching self-efficacy change after their exposure to the STEM semester? (2) How do preservice elementary teachers (PETs) conceptualize integrated STEM instruction at the beginning and end of the STEM semester? Data sources include pre- and post-course administrations of the self-efficacy beliefs for Integrated STEM (SETIS), an open-ended questionnaire, written STEM autobiographies, and STEM reflective journals. Dependent sample t-test analysis was used to investigate the significant mean differences between the pre-and post-tests mean scores. The results indicated statistically significant gains in participants' integrated STEM self-efficacy beliefs. Thematic analysis revealed positive shifts in participants' perceptions of STEM teaching and learning as well as increased confidence in designing and implementing integrated STEM instruction in the future. Furthermore, participants shifted away from STEM stereotypes and emphasized STEM learning for "all" students. Implications for preservice STEM teacher preparation programs and research that enhance integrated STEM teaching self-efficacy are discussed.

Effects of Virtual Lab Activities on Elementary Pre-Service Teachers' Self-Efficacy in Teaching Science

Soon Lee*, Kennesaw State University, USA

ABSTRACT
Studies have suggested that certain combinations of hands-on (HL) and virtual lab (VL) activities would be able to capitalize on the features of each approach to better support student learning. Many studies have shown certain combinations of HL and VL activities to produce higher learning gains. However, other studies found no differences in students' conceptual understanding between different combinations of VL and HL, provided students were engaged in both. However, no studies have investigated whether the comprehensive use of VL activities yields better results for student learning outcomes than brief uses of them. In this study, the author developed a curriculum for his physical science content course with HL and VL activities. He then implemented the curriculum differently over three consecutive semesters; each semester's curriculum implemented a different combination of HL and VL activities. The findings from this study show that engaging PSTs in VL activities, even briefly, in addition to HL activities improved their physical science content knowledge and self-efficacy in teaching science to a greater extent than with HL activities only. The findings also confirmed

the correlational relationships between PSTs' self-efficacy and their physical science content knowledge.

Strand 8: In-service Science Teacher Education
SC-Organized Paper Set: Supporting Teachers To Support Student Talk: Multidimensional Examination of Collaborative and Participatory Professional Learning Contexts
4/21/23, 13:45-15:15, Salon C1-2 (LL)

Exploring the Personal Domain: Noticing Task as New Method and Descriptive Analyses of Change

Jennifer Schellinger*, Florida State University, USA
Asli Kaya, Florida State University, USA
Ryan Coker, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT
A teacher's noticing or their ability to see and interpret classroom events is an important component of their expertise. Examinations of these noticings is a way to understand changes in their learning over time. In this research, we examine changes in teacher noticing of classroom instruction for two groups that participated in slightly different professional development experiences to understand how this PD shaped their personal domain of learning. Findings suggest that both programs shaped teacher noticing and learning but in different ways.

Exploring the Domain of Practice: Documenting Outcomes of PDs by Examining Teachers' Instructional Practices

Patrick Enderle*, Georgia State University, USA
Ozlem Okan, Florida State University, USA
Ryan Coker, Florida State University, USA
Sierra Morandi, Florida State University, USA
Jennifer Schellinger, Florida State University, USA
Miray Tekkumru-Kisa, RAND, USA
Sherry Southerland, Florida State University, USA

ABSTRACT
Using the IQA-SOR instrument, we analyzed participating teachers' classroom implementation of instructional resources and models. Teachers who collaboratively designed their materials for the focal lessons demonstrated more rigorous implementation, while those who only experienced the focal lessons during the PD experience did not implement as rich of instruction. However, all participating teachers did show strengths in implementing particular aspects of the focal lessons.

Exploring the Domain of Consequence: Examining Changes in Students' Scientific Reasoning and Affect

Kari Roberts*, Florida State Univerity, USA
Jennifer Schellinger*, Florida State University, USA
Patrick Enderle*, Georgia State University, USA
Sierra Morandi*, Florida State University, USA
Harini Krishnan, Florida State University, USA
Sherry Southerland*, Florida State University, USA

ABSTRACT
This paper examined changes in students' biological reasoning, scientific sensemaking, valuing of science, and fascination in science over the course of a school year after their teacher participated in one of the two professional development programs. One professional development (PD) group emphasized teacher collaboration in revising materials for their classroom, while the other emphasized revision of materials without collaboration among teachers. Results from repeated measures ANOVA showed showed improvements in students' biological reasoning from the beginning to end of the school year when in classrooms lead by teachers who participated in the collaboration-focused PD. Students' scientific sensemaking, valuing of science, or science fascination remained stable across the school year across both PD groups.

Exploring the External Domain: Describing the Role of Collaboration on Teacher Learning

Sherry Southerland*, Florida State University, USA
Allison Metcalf*, Florida State University, USA
Jennifer Schellinger, Florida State University, USA
Harini Krishnan, University of Utah, USA

ABSTRACT
Researchers of teacher education have long advocated that one of the most essential supports to teacher learning of novel instruction practices comes from collaboration. Much of the collaboration literature focuses on the outcomes of teacher collaboration without providing insight into the nature of collaborations. In this work, we seek to understand the collaboration that occurred between five school biology teachers as they designed, enacted, and reflected on a lesson emerging from professional development focused on productive talk. The questions guiding this work include: What was the focus of the LCD teacher group's collaboration?, What was the nature of the LCD teacher group's collaboration? and, What role did the group's collaboration serve in supporting each teacher's practice? We found that the collaborative space opened-up opportunities for teachers to discuss their practice for the lesson and outside of the lesson itself. Salient to the collaborative space was a sense of support between the teachers as teachers intensively listened to one another, normalized a problematic issue as well as the emotions that they were experiencing by relating to each other, providing advice and words of encouragement. Teachers' collaboration eased the work of designing and enacting a conceptually challenging lesson.

Concurrent Session 13, 4/21/23, 13:45-15:15

Exploring the Personal/External Domains: Investigating Changes in Epistemic Orientations During Sustained Collaborative Professional Learning

Sierra Morandi*, Florida State University, USA
Jennifer Schellinger*, Florida State University, USA
Kari Roberts*, Florida State University, USA
Patrick Enderle*, Georgia State University, USA
Ellen Granger, Florida State University, USA
Sherry Southerland, Florida State University, USA

ABSTRACT

Current reform efforts in science education focus on creating environments where students grapple with and negotiate their own understandings and mechanistic explanations of scientific phenomena by using their knowledge of disciplinary content and science practices. In order to support this reformed vision, effective professional development (PD;) for science teachers is critical. If PD is to shape teachers' practice, teachers must experience a change in attitudes and beliefs. The research presented here explores the epistemic orientation of three secondary science teacher cohorts who were supported in different iterations in a larger professional development study. The epistemic orientation toward teaching science survey was administered at three time points for each cohort and paired sample t-tests were performed to analyze composite and dimensional scores. Our analysis revealed that change in epistemic orientation occurred for teachers who engaged in two years of supportive PD, but that one year of support was not sufficient to engender change in epistemic orientations. These findings further support the need for continuous, high-quality, longitudinal PD when the goal is a shift in science teachers' epistemological beliefs and teaching practices.

Strand 8: In-service Science Teacher Education

Symposium: Symposium on Science Teacher Leadership from Research and Practice Perspectives

4/21/23, 13:45-15:15, Salon C3-4 (LL)

Symposium on Science Teacher Leadership from Research and Practice Perspectives

Sara Heredia*, University of North Carolina at Greensboro, USA
Michelle Phillips, Exploratorium, USA
Tammy Cook-Endres, Exploratorium, USA
Corene Duarte, Oxnard Union High School District, USA
Brooke Whitworth, Clemson University, USA
Meredith Schwendemann, Clemson, USA
Amanda Gonczi, Michigan Technological University, USA
Laura Ruelas, Kalamazoo Public Schools, USA
Todd Campbell, University of Connecticut, USA

ABSTRACT
In this symposium, we bring together researchers and practitioners to discuss professional learning programs and the needs of science teacher leaders in the age of NGSS. Science teacher leaders have been named as a key lever for the implementation of science education reform. We argue that it's necessary to provide focus on science teacher leaders because of their unique needs when supporting science education including, material and resource management for experimentation and engineering activities, knowledge of how scientific knowledge is changing through new research, and a lack of attention to science education reform efforts at the administrative level due to high-stakes assessments in ELA and math. Three different professional learning programs will be represented at the symposium and participants will hear from both researchers and practitioners, including science teacher leaders working in the field. Our discussant will provide over-arching remarks related to the three projects and their own work in STEM teacher leadership.

Strand 10: Curriculum and Assessment
Related Paper Set: Unpacking "Relevance" as a Design Aim for Instructional Materials: In What Ways? For Whom?
4/21/23, 13:45-15:15, Salon A4 (LL)

Relevance in Teachers' Customization: Data from a Pilot Survey on PCK for Equitable Sensemaking

Jason Buell*, Northwestern University, USA
Yang Zhang, Northwestern University, USA
Brian Reiser, Northwestern University, USA
Kelsey Edwards, Northwestern University, USA

ABSTRACT
This poster presents data from a pilot survey on teacher's PCK for equitable sensemaking where teachers were provided with vignettes describing customizations a teacher made to their curriculum and their reasoning for doing so. Respondents were asked to select whether these customizations would increase or inhibit opportunities for equitable sensemaking. In two open-ended questions, teachers were provided with a curricular example and asked to make their own customizations. This poster presents the results, with a focus on how teachers attempt to use their ideas of what is relevant to their students in order to make curricula more equitable. We find that customizations related to relevance always involve some change to the phenomenon and often presume some homogeneity of the students' experiences. In addition, teachers typically take on a definition of relevance relating to personal familiarity rather than social transformation. We see this poster as contributing to research on how teachers typically leverage relevance for equitable purposes when customizing curriculum. We see particular areas for growth in helping teachers to find ways to determine for whom this is relevant, identifying areas for customization in addition to making changes to the phenomenon, and in moving beyond personal familiarity.

From Superficial to Foundational: Integrating Cultural Relevance with Computer Science Content and Pedagogy

Amanda Nolte, University of Delaware, USA
Diane Codding*, Northwestern University, USA
Rosalie Rolon-Dow, University of Delaware, USA
Chrystalla Mouza, University of Illinois Urbana-Champaign, USA
Lori Pollock, University of Delaware, USA

ABSTRACT
Female and minoritized groups continue to be underrepresented in computer science (CS) and STEM careers, despite ongoing efforts to diversify the field. One way to promote the success of minoritized students in CS education is to incorporate culturally responsive pedagogy (CRP) into CS curriculum and instruction. This work explores the ways that teachers integrated CRP in their lesson plans following CRP-focused professional development (PD) sessions delivered during a week-long PD aimed at improving and diversifying CS education. Our analysis of the lesson plans reveals that teachers integrated CRP at levels ranging from superficial to foundational. At the superficial level, teachers treated CRP as an "add-on" to their planned lessons, lacking integration with lesson content. At the foundational level, teachers integrated CRP as a central feature of their lesson plans. This work contributes to our understanding about how teachers approach the concept of relevance when integrating CRP in CS education. Findings have implications for approaches to PD designed to support teachers in integrating CRP in CS education, as well as other STEM classrooms.

Agentic Teaching: Strategic Science Curriculum Adaptation for Relevance

Nicholas Leonardi*, University of Illinois at Urbana-Champaign, USA
Barbara Hug*, University of Illinois at Urbana-Champaign, USA
Christina Krist, University of Illinois at Urbana-Champaign, USA

ABSTRACT
This study explores how a teacher adapted a curriculum for relevance, and how what "relevance" means shifted based on various contextual conditions. The poster presents data from ethnographic interviews and fieldnotes taken in one classroom with one teacher during the enactment of a co-designed unit. We find that the teacher participant adapted the curriculum to make it relevant to students by supplementing the original phenomenon with local and familiar examples. The teacher saw the local example as a way to stress the proximity and impact of the phenomenon, and support students in asking questions. The teacher viewed the familiar example added later in the unit as a way for students to make connections to the original phenomenon, and as a tool to narrow the factors considered for experimentation. We argue that the type of relevance selected was strategic on the part of the teacher in order to support students in the doing of science. We see opportunities to make explicit the various types of relevance, so teachers understand the resources available to them when making decisions about how to adapt a curriculum.

Co-Designing for Relevance in NGSS-Aligned Performance Assessments

Jennifer Richards*, Northwestern University, USA
Kevin Cherbow*, BSCS, USA
Miray Tekkumru-Kisa, Florida State University, USA
J. Richey, University of Pittsburgh, USA

ABSTRACT

In the NGSS era, science assessments need to enable students to demonstrate three-dimensional competencies as they seek to address relevant phenomena or problems. This qualitative study focuses on senses of relevance that entered into assessment co-design conversations among middle school science teachers and science education researchers. We asked: In what ways was relevance considered and designed for during assessment co-design? Drawing on video and artifacts from nine co-design sessions, we identified and characterized episodes of pedagogical reasoning (Horn, 2005) in which relevance was a consideration. The majority of episodes focused on personal or local connections for students, consistent with prior work (e.g., Hancock et al., 2019). However, the ways in which teachers designed for student choice in service of this provide a promising strategy that foregrounds student agency and could be adapted across contexts. Some episodes also involved negotiations among forms of relevance, which are critical for science education that not only connects to students' lives and communities but supports them in participating as global citizens. In sum, this study provides a needed examination of how relevance may be considered in the design of NGSS-aligned assessments and supported through co-design.

Attending to Student Interest and Identity in Instructional Phenomenon

Kate Henson*, University of Colorado, USA
William Penuel, University of Colorado, USA

ABSTRACT

In the NGSS era, science assessments need to enable students to demonstrate three-dimensional competencies as they seek to address relevant phenomena or problems. This qualitative study focuses on senses of relevance that entered into assessment co-design conversations among middle school science teachers and science education researchers. We asked: In what ways was relevance considered and designed for during assessment co-design? Drawing on video and artifacts from nine co-design sessions, we identified and characterized episodes of pedagogical reasoning (Horn, 2005) in which relevance was a consideration. The majority of episodes focused on personal or local connections for students, consistent with prior work (e.g., Hancock et al., 2019). However, the ways in which teachers designed for student choice in service of this provide a promising strategy that foregrounds student agency and could be adapted across contexts. Some episodes also involved negotiations among forms of relevance, which are critical for science education that not only connects to students' lives and communities but supports them in participating as global citizens. In sum, this study provides a needed examination of how relevance may be considered in the design of NGSS-aligned assessments and supported through co-design.

Exploring the 'What' and 'Why' in Student Co-Created Computer Science Curricula

Bradley Davey*, Northwestern University, USA
Sepehr Vakil, Northwestern University, USA

ABSTRACT

Discussions of relevance in science education rarely include student voices. This poster reports findings from a seven-week afterschool pilot program that positioned youth as co-designers of computer science curricula. We qualitatively analyzed curricular materials to identify what youth found relevant and why. We found, among other things, that youth center technical aspects of emerging technologies (NFTs and cryptocurrencies) alongside their sociopolitical implications. This contrasts traditional emphases on reading, writing, and interpreting code that underpin learning about technologies in computer science education. We conclude with possible connections for computer science and science education reform movements that take seriously a call for centering relevance in students' learning experiences.

Determining Relevance in A Nation-Wide Curriculum Co-Design Process

Katarzyna Pomian Bogdanov*, Northwestern University, USA

ABSTRACT

In this poster I examine discussions of relevance during weekly co-design meetings of teachers and researchers working together to create storyline driven and NGSS supporting instructional materials. The focus of the design work was largely on coherence from the students' perspective by building curricula from an anchoring phenomena and supporting students in driving the unit. This creates many areas for the team to discuss what is relevant to students. I focus on moments during which design dilemmas occurred and examine the utterance level of participant interactions. I explore how decisions about what is relevant to include in a nation-wide curriculum are made through deliberations during design meetings and what aspects of relevance are aimed to be balanced. The aspects of relevance I look at include: coherence from the students' perspective, student engagement, and equity focused science education.

Strand 11: Cultural, Social, and Gender Issues
Symposium: Creating reflexive and critical spaces: International perspectives on working with teachers towards equitable science education
4/21/23, 13:45-15:15, Salon C5-6 (LL)

Creating reflexive and critical spaces: International perspectives on working with teachers towards equitable science education

Christina Siry*, University of Luxembourg, Luxembourg
Sara Wilmes*, University of Luxembourg, Luxembourg
Carla Zembal-Saul, The Pennsylvania State University, USA
David Segura, Beloit College, USA
Maria Varelas, University of Illinois, USA

Nina Hike, University of Illinois, USA
Darrin Collins, University of Illinois, USA
Daniel Morales-Doyle, University of Illinois, USA
Jennifer Adams, University of Calgary, Canada
Sarah El Halwany, University of Calgary, Canada
Sophia Marlow, University of Calgary, Canada
Kristal Turner, University of Calgary, Canada

ABSTRACT
This symposium will explore spaces for teachers and teacher educators to reflexively and critically examine their praxis with a goal of highlighting approaches that work towards equity and social justice in science education. Grounded in perspectives that situate science as cultural enactment, schools are framed as sites of social (re)production, and as such, teachers are the enactors of systems and practices (Tobin, 2012), playing a pivotal role in upholding, or dismantling, systems that seek to standardize, normalize, and generalize. The authors seek to push-back on pressures to standardize science teaching and learning, and in doing so, to expand the boundaries of possibilities for science education. Collectively the international panelists from five research groups will share how they carve out and hold space to critically examining with teachers what is being enacted throughout all aspects of our work with children, students, and families. Panelists will present from their research around two central questions: i) What is the nature of critical and reflexive spaces in our work? ii) What do these spaces afford teachers and teacher educators? This will provide groundwork for discussion among symposium attendees and panelists around lessons learned and future steps to make space for reflexivity and criticality.

Strand 11: Cultural, Social, and Gender Issues
SC-Organized Paper Set: Science Identity for k-12 Learners: Where we've been, where we're going
4/21/23, 13:45-15:15, Salon A1 (LL)

A Brief Review of Secondary Physics Identity Research in the United States

Kate Miller*, Michigan State University, USA
Terrance Burgess*, Michigan State University, USA

ABSTRACT
The Next Generation Science Standards (NGSS) explicitly foregrounds issues of equity and diversity, emphasizing students' multiple identities as a key component of inclusive science instruction. In response, this paper asks: Since the emergence of the NGSS, how have contemporary scholars conceptualized physics identity within the secondary science education literature in the United States? A total of eight articles are considered in this literature review, leading to four key findings: 1) there is limited research focused on this topic; 2) the focus is primarily on gender and/or racial identities; 3) justifications for secondary physics identity research center on students gaining access to college and career opportunities; and 4) there is

a focus on teachers' classroom moves. Corresponding recommendations include: 1) a call for more research on this topic; 2) an additional focus on other identities along with greater attention to intersectionality; 3) a more expansive set of justifications for this work; and 4) a need for further investigation into physics teacher identity development and decolonized physics curricula and pedagogy. With these considerations, we can better understand the complexities of students' physics identity construction with the goal of creating more equitable and inclusive secondary physics experiences.

How do Students' Science, Mathematics, and Nature Identities Impact Students' Interest in STEAM Careers?

Michelle Parslow*, Utah State University, USA
Katherine Vela*, Utah State University, USA
Kathy Trundle, Utah State University, USA
Rita Hagevik, University of North Carolina, USA
Laura Wheeler, Utah State University, USA
David Joy, Wahlquist Junior High School, USA

ABSTRACT
As the number of available science, technology, engineering, and mathematics (STEM) careers increases faster than the number of students who are majoring in STEM fields (Dorssen et al., 2006; Torlakson, 2014), teachers try to prepare STEM-literate students, paying special attention to female students, while supporting or increasing their interest in STEM careers (Mohr-Schroeder et al., 2022). We conducted research on how public junior high school students' (n=326) science, mathematics, and nature identities correlated with their interests in STEAM careers and the relationships in interest between these careers. Data were analyzed through Cohen's d effect sizes, t-tests, and correlation matrices. Our findings showed statistically significant differences in science and nature identities between female and male students. Specifically, male students expressed a 0.3 standard deviation higher in mean difference than their female counterparts for science identity. While female students expressed a 0.44 standard deviation higher in mean difference than their male peers for their nature identity. There were statistically significant positive correlations between science, mathematics, and nature identities and interest in science and mathematics careers. There were also many significant positive correlations between interest in various individual STEAM careers. Finally, we discuss the implications for teachers, researchers, curriculum writers, and policymakers.

Who Can be a Scientist?: Youth perceptions of STEM pathways

Alexandria Muller*, University of California, Santa Barbara, USA
Natalie Churchley, University of California, Santa Barbara, USA
Tiffany Yun, University of California, Santa Barbara, USA
Liliana Garcia, University of California, Santa Barbara, USA

ABSTRACT
The retention of STEM students is not high enough to meet the growing demand for STEM professionals. Many interventions have been tested to increase student interest in STEM but knowledge of how to achieve one's goal is just as important as interest in STEM. As such, we

were interested in understanding how youth perceive the pathway to becoming a STEM professional. We used interviews with students in grades kindergarten through 7th to understand the perceptions elementary students have of the pathway to becoming a STEM professional. In this paper, we focus specifically on student perceptions of a science career and discuss the two main emergent themes: students believe that becoming a scientist is an achievable goal with hard work and becoming a scientist is dependent on the inherent traits of a person. These findings can help inform the efforts of intervention developers and STEM education researchers to better target the perceptions of students that serve as a barrier to pursuing STEM careers.

Considering Possibilities for Identity Expansion: A Grounded Theory of Youths' STEM Identity Play

Alison Mercier*, University of Wyoming, USA
Heidi Carlone, Vanderbilt University, USA

ABSTRACT

There are many different models of longitudinal identity development in the literature. They generally acknowledge that crafting identities involves some combination of authoring oneself amidst various structural arrangements and leveraging material, relational, and ideational resources. These models assume a directionality towards or away from STEM over time. This paper introduces STEM identity play to understand youths' identity development in non-linear and less directional ways. Informed by the constructs of wayfaring, rhizomatic thinking, and plastic continuity, we provide a case of one youth's identity play during out-of-school STEM learning focused on environmental problem solving. Her identity play was evident in performances and narrations of self over time where she tried out different ways of STEM knowing and doing in identity affirming and expansive ways.

Strand 14: Environmental Education and Sustainability
SC-Organized Paper Set: Community environmental issues
4/21/23, 13:45-15:15, Blvd C (L2)

Epistemological Plurality for Globally Situated Science Discourse

Mary Short*, 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, 1996, p.1). In this vein, the very stuff that makes up knowledge, the basic building blocks of our cognition are also associated with and influenced by globalization. Therefore, the era of globalization demands that scholars expand how they approach understanding student epistemology for the current era. Multiple scholars have called for reorienting science research on student epistemology for multiple ways of knowing as a way to expand the possibilities of human knowledge, recognize the socially and culturally

embedded nature of knowledge construction, and deconstruct epistemic hierarchies to create pathways for unsettling myths of science that are deeply embedded in racism, sexism, and colonialism. This paper builds on the work of researchers already engaged in this task by presenting qualitative findings to illustrate epistemological plurality during classroom discourse about a global ecological issues.

Co-creating the Discourse of Environmental Consciousness toward Justice in Science Classrooms

Won Jung Kim*, Santa Clara University, USA
Lisa Archuleta, Santa Clara University, USA

ABSTRACT

This study reports a case that involves a teacher educator, June (first author), a teacher Teresa (the second author), and Teresa's students for co-creating and expanding the discourse of environmental consciousness in a science classroom towards justice. We designed, implemented, and reflected on environmental consciousness science units (shortly EC units), with which we sought to address environmental justice concerns as students engaged with standards-informed knowledge and practices. Using a reflexive thematic analysis of data we generated across our work on the EC unit as we refer to the conceptual framework established upon the literature of sociopolitical consciousness and environmental justice, we document the EC unit on the topic of over-consumption that involves activities for sociopolitical consciousness. We identified two core themes of classroom discourse toward justice: (1) pedagogical obligations to support students' use of science practices toward distributive and transformational environmental justice. (2) students' rights to be recognized for and participate in the exposure and examination of environmental injustices. This study's implications for teacher education research and practice are discussed.

Centering Social Justice in K-12 Place-Based Education

Meena Balgopal, Colorado State University, USA
Elizabeth Diaz-Clark*, Colorado State University, USA
Laura Sample McMeeking, Colorado State University, USA
Andrea Weinberg, Arizona State University, USA

ABSTRACT

To help develop teachers as ‘agents of change,' teachers need support and guidance to center social justice in their lessons. Addressing place attachment and emphasizing citizen engagement, the use of Place Based Education (PBE) can help teachers develop curriculum to meet academic standards while empowering students to draw on their own funds of knowledge and become engaged citizens. In our exploratory study, we examined a semester-long course that paired in-service and pre-service science or integrated STEM teachers and was designed to model how PBE lessons can center social justice. Participants (n=12) engaged in lessons on locally relevant socio-scientific issues before designing their own. Using our integrated PBE model and PLACE frameworks, we examined several course artifacts to identify how (a) social justice and (b) aspects of the frameworks were integrated (or not) in participant-developed PBE lessons. We found that teachers incorporated many crucial

components but underdeveloped a focus on cultural funds of knowledge, interdisciplinary activities, and promotion of students' civic engagement. We determined that teachers need sustained support through a greater emphasis on peer review, more locally-relevant resources, and increased opportunities for the exploration of more nuanced and complex views of place-based socioscientific issues and diverse stakeholders.

Community science literacy as a sociomaterial practice rooted in place

Christopher Jadallah*, University of California, Davis, USA
Heidi Ballard, University of California, Davis, USA

ABSTRACT
Conceptualizing science literacy as a community endeavor can guide the design of informal science learning environments that support moves toward social-ecological transformation. To identify and describe the factors that mediate processes of community science literacy, we studied its emergence as a social practice in the context of two community-based watershed monitoring programs where scientists, science-related professionals, and community members worked collaboratively to monitor the health of a local creek following dam removal. Through analysis of ethnographic observations and interviews with program participants, we describe how elements of both the material and natural world come to mediate how participants coordinate with each to advance the work of watershed monitoring. Specifically, we found that both material artifacts and the natural world aid in the completion of scientific tasks, particularly as it comes to navigating uncertainty, and shape decision-making around project design. We also found that understandings of materiality and the natural world cannot be separated from issues of power, status, and rank. These findings serve to extend understandings of community science literacy as a socialpractice to a sociomaterial practice rooted in place, with implications for structuring learning environments that support diverse sets of actors in working together for social-ecological change.

Closing Session

4/21/23, 15:15-16:15, Salon A1 (LL)

Looking ahead to the 2024 Conference

Gillian Roehrig, outgoing NARST President: Showing appreciation for Board and Committee leadership
Jomo Mutegi, incoming NARST President: NARST Goals and Inspiration

Virtual Conference Day
Opening Session
7:00-7:30, Zoom A

The all-virtual conference day will open with remarks by outgoing President Gillian Roehrig, and incoming President Jomo Mutegi

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Concurrent Session 1

4/28/23, 7:45-8:45

Multistrand Paper Set: Representations of Science

4/28/23, 7:45-8:45, Zoom A

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

The representation of nature of science in grade 6 French, American and CountryL science textbooks

Marie-Noel Salem*, American University of Beirut, Lebanon
Saouma BouJaoude, American University of Beirut, Lebanon

ABSTRACT

Textbooks are relied upon as the main resource for teaching. The Nature of Science (NOS), now part of many curricula, is considered essential for students to achieve scientific literacy. Consequently, many textbooks now address NOS. The Family Resemblance Approach (FRA) has been newly developed to give a holistic overview of NOS and it was used in this study to analyze 7 textbooks used in CountryL. Consequently, the purpose of this study was to investigate the representation of NOS in textbooks published by American, French publishers using the FRA to NOS framework and compare them CountryL's national textbook. Following an inter-rater reliability test, three American, three French, and CountryL's grade 6 science textbooks were read in their entirety and analyzed. Results showed that in American textbooks, most NOS categories were represented while French and CountryL textbooks had many NOS categories unrepresented, which were mostly from the social-institutional aspects. Moreover, CountryL textbook had the highest occurrence for the knowledge category. Finally, while American textbooks tended to have the highest number of occurrences for representation, French textbooks tended to have higher percentages for high-quality representation. The results of this research can be used by schools in their choice of textbooks.

Strand 1: Science Learning: Development of student understanding

Investigating Science Process Skills of Middle School Students

Fatma Uçar*, Hasan Kalyoncu University, Turkey
Semra Sungur, Middle East Technical University, Turkey

ABSTRACT

Science process skills are one of the essential elements in effective science education, and it has become increasingly important for arising individuals who can access, produce, interpret and use information during the latest decades. This study explored students' understanding of science process skills using a qualitative research design. The data were obtained by interviewing 12 seventh-grade students individually. The results revealed that students had some misunderstandings related to hypothesizing, identifying variables, inferring and observing, predicting, and interpreting data. They were also inadequate in planning an experiment. These findings suggested that curriculum developers, science teachers, and

teacher educators should take necessary actions to promote the adequate understanding and development of these skills.

Multistrand Paper Set: Exploring Ideas in STEM
4/28/23, 7:45-8:45, Zoom B

Strand 7: Pre-service Science Teacher Education

Adaptive Expertise in Math and Science Teaching: Differential Impact on Preservice Teachers' iSTEM Teaching Attitudes

Mounir Saleh*, UOB, Bahrain
Bashirah Ibrahim, UOB, Bahrain

ABSTRACT

Integrated Science, Technology, Engineering, and Mathematics (iSTEM) teaching prepares students for 21st-century challenges. Nevertheless, teachers' attitudes influence the implementation of iSTEM teaching. Hence, studying factors that impact these attitudes is useful. Teachers' predisposing and enabling factors are yet to be investigated. One construct that includes both factors is adaptive expertise (AE). Teachers with AE tend to show willingness and ability to learn and innovate new teaching approaches. We used a cross-sectional survey method with 71 senior preservice teachers (PSTs) to test our hypothesis that teachers' attitudes toward iSTEM teaching are affected by their AE in teaching that shares domain-relevant and familiar strategies with iSTEM teaching. We employed AE in math and science teaching as model domains. Regression analysis revealed that, unlike AE in math teaching, AE in science teaching positively impacted our PSTs' attitudes toward iSTEM teaching. We attribute this differential impact to the type of teaching practices that PSTs based their AE on. Unlike in math, PSTs' AE in science teaching was based on practices that are directly related to iSTEM teaching strategies. The findings of this study have promising implications for the design of teacher preparation programs.

Strand 12: Technology for Teaching, Learning, and Research

Technology-Enhanced Differentiated Instruction in STEM Education: Teacher Candidates' Development of Digital Educative Curriculum Materials

Mohammed Estaiteyeh*, Western University, Canada
Isha DeCoito, Western University, Canada

ABSTRACT

Differentiated instruction (DI) is a teaching approach that aims to achieve learning for diverse students. This research focuses on intermediate-secondary STEM teacher candidates' (TCs') training to promote DI using technological tools. The overall study explores the impact of DI-focused strategies in a course in Teacher Education at a Canadian university on STEM teacher candidates' (TCs') understandings and implementation of DI. This paper addresses two research questions: 1) What models of technology-enhanced DI do TCs incorporate in their lessons? 2) If, and to what extent are digital resources effective tools to implement DI in secondary science classes? The authors present the analysis of one course assignment in which TCs developed multimedia curriculum resources websites suitable for use by secondary

STEM teachers. The analysis of 18 websites shows how the STEM course supported TCs to utilize digital educative curriculum materials while integrating DI principles and practices. TCs were able to design lesson plans and curriculum resources that are differentiated in content, process, and product. Furthermore, TCs' work on digital resources highlights the potential of technology in facilitating DI in secondary science classes by facilitating pacing variation for different students, integrating multimodalities, utilizing engaging features, representing different learners, and enabling different assessment forms.

Strand 10: Curriculum and Assessment

Design, Enactment, and Redesign of a STEM Curricular Unit

Tasneem Anwar*, Institute for Educational Development, Aga Khan University, Pakistan

ABSTRACT

This paper aims to showcase the outcome of a Pakistani practitioner-researcher partnership that resulted into design-based STEM curricular unit development. This paper shares the design, enactment and redesign of one of the designed -based STEM curricular units- ‘Mangolicious' that was developed by a team of three classroom teachers, their STEM coach and the author. This paper offers two significant findings: 1). The STEM model that evolved because of this STEM focused professional development that engaged teachers in curriculum design, and 2). Design principles that guided the redesign of the STEM Curricular unit ‘Mangolicious'. The first finding presents a Pakistani STEM model that has engineering design as the core piece. Whereas the four design principles for developing design- based curricular units will be a guide for many such endeavors. These takeaways have direct implications for teacher educators for national level implementation of STEM in Pakistan. Whereas this study offers interesting insights for the international researchers especially the North American researchers allowing them to visualize the transfer and adaptation of STEM reform in a country that is one of the most recent adopters.

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

Reasoning About the Technological Aspects of Societal Issues: Insights from Technology Studies

Jacob Pleasants*, University of Oklahoma, USA

ABSTRACT

An enduring goal for science education is to prepare students to be better-informed and more well-reasoned decision makers in our modern society. Reasoning about complex socioscientific issues requires an understanding of science concepts and practices, but also the ability to examine issues from multiple perspectives, recognize the limitations of science, and more. Novel technologies often lie at the heart of socioscientific issues, which means technological reasoning is an important component of socioscientific reasoning. However, this is an area that has received relatively little attention. The goal of this paper is to clarify what it means to reason about technology in sophisticated ways. To do this, I leverage an extensive body of Technology Studies scholarship, which includes studies of technology from history, philosophy, sociology, and psychology. This work indicates that careful thinking about technology requires attending to dimensions and aspects that often lie hidden from everyday view. Technological reasoning requires attending to the political and psychosocial dimensions

of technology as well as its technical dimension. It also requires examining how technologies are embedded in various technical and social systems, as well as how they intersect human values. Practical tools and implications for science teaching are addressed.

Breakout Room Discussions
8:45-9:15
Zoom A and Zoom B

Multiple breakout rooms will be available for open discussion.

Concurrent Session 2

4/28/23, 9:30-10:30

Multistrand Paper Set: Science Education Research Innovations

4/28/23, 9:30-10:30, Zoom A

Strand 12: Technology for Teaching, Learning, and Research

Augmented Culturo-Techno-Contextual Approach (CTCA) for Teaching and Learning a Concept in Computer Study

Michael Adewusi*, Lagos State University (LASU), Ojo ACEITSE, Nigeria
Ola Tokunbo Odekeye, Lagos State University (LASU), Ojo ACEITSE, Nigeria
Olugbenga Akindoju, Lagos State University (LASU), Ojo, Nigeria
Silas Egbowon, Lagos State University (LASU), Ojo, Nigeria
Mukaila Rahman, Lagos State University (LASU), Ojo, Nigeria
Michael Ahove, Lagos State University (LASU), Ojo ACEITSE, Nigeria

ABSTRACT

The use of augmentation technology and the CTCA for educational purposes may go a long way toward building multiple intelligences that would enable students to participate in learning activities with greater success, as this study might be among the first to demonstrate such combinations reported in literature. However, in a learning environment, no single technological application or device can fully develop all of a student's intelligence.

Strand 14: Environmental Education and Sustainability

Using Place-Based SSI Instruction that Utilizes Role-Playing to Promote Preservice Teachers' Socioscientific Accountability and NOS

Banu Avsar Erumit*, Recep Tayyip Erdogan University, Turkey
Bahadir Namdar, Ege University, Turkey
Aysegul Oguz Namdar, Recep Tayyip Erdogan University, Turkey

ABSTRACT

This mixed-method design study aimed to investigate the impacts of place-based instruction enhanced with the role-play activities on promoting preservice teachers' [PSTs] understanding of the NOS views, their character and values, and specifically socioscientific accountability (feeling responsibility and willingness to act) as global citizens regarding climate change and global warming issues. The study took place at a public university in Turkey, and the participants were 20 preservice middle school science teachers. We engaged PSTs in local climate issues with field trips to several local places. We explicitly used contextualized NOS in role-playing scenarios to promote PSTs' holistic and contextualized understanding of NOS. We used the "Character and values as Global Citizens Assessment" [CVGCA] scale as the quantitative data source and pre- and post- one-on-one semi-structured interviews to understand; PSTs' contextualized understanding of NOS on climate change and global warming, PSTs' feelings of responsibilities and willingness to act on local and global climate issues as the qualitative data source. The results showed that place-based SSI intervention

and related role-play activities improved students' contextualized NOS views and developed their character and values, particularly their feeling of responsibility and willingness to act as global citizens.

Strand 12: Technology for Teaching, Learning, and Research

Quality Assessment of Written Reflections by Computer-Based Structural Analysis

Lukas Mientus*, University of Potsdam, Germany
Peter Wulff, Heidelberg University of Education, Germany
Anna Nowak, University of Potsdam, Germany
Andreas Borowski, University of Potsdam, Germany

ABSTRACT

Reflection on teaching lessons is often seen as a key category in the context of teachers' professional development. However, valid and reliable assessment of reflective competencies is complex and resource consuming. Some of the complexity and resource issues could be tackled with the help of natural language processing and machine learning (ML). It remains unclear to what extent these computational analyses allow the valid assessment of the quality of a written reflection. Consequently, we modelled the information in the written reflections in several steps in order to assign a Level of Structure (LOS) to each text. To do so, the pre-trained ML-algorithm from authors was used to segment and categorize N = 110 written reflections on a video sequence of a physics lesson. Based on this data, we devised and calculated a quality measure that we call Level of Structure (LOS). Four domain experts were given a subset of written reflections to rate their quality in comparison. Our results show, that in extreme groups LOS is a valid indicator of the quality of the written reflection especially for less-structured texts. The presentation will give the NARST community an example of what insights computer-based analyses allow.

Strand 11: Cultural, Social, and Gender Issues

ITPOP: Development of an instrument for observing inclusive teaching practices in undergraduate science classrooms

Hai Nguyen*, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, University of Missouri-Columbia, USA
Marcelle Siegel, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, and Department of Biochemistry, University of Missouri-Columbia, USA
Natalia Franca, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, University of Missouri-Columbia, USA
Saaedah Albishi, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, University of Missouri-Columbia, USA
Ritesh Sharma, Department of Learning, Teaching, and Curriculum, College of Education and Human Development, University of Missouri-Columbia, USA
Yejun Bae, Moore School of Education, Carolina University, USA

ABSTRACT

As calls for inclusive instruction in STEM programs are unambiguous, it is essential to advance initiatives that facilitate inclusion in the classroom. These programs involve the invention and

development of tools that can measure the expansion of inclusive settings in higher education. In this study, we developed a new instrument for measuring inclusive practices and employed a mixed - method approach, including a thorough analysis of video recordings and interpretations based on fieldnotes. We conducted a total of six observations with four instructors of STEM courses in undergraduate programs. Based on our data, we conclude that inter-rater reliability is sufficient. This is a preliminary finding that demonstrates the potential for further discussion regarding pedagogical opportunities and challenges for the complex task of developing an observation protocol of inclusive teaching practices, as well as the methodological considerations of validity, reliability, and consistency of the instrument. Our full paper will provide ideas on how to build and enhance an instrument that promotes inclusive higher education practice. This work will be of interest to NARST members and academics interested in analyzing equitable learning environments because it can inform inclusive teaching strategies in interdisciplinary STEM fields.

Multistrand Paper Set: Seeing Science Education Differently
4/28/23, 9:30-10:30, Zoom B

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

Sequential Synthesis Problem-Solving: Do Correct and Incorrect Problem Solvers' Gaze Patterns Differ?

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

ABSTRACT

Sequential synthesis problems involve a series of events that require the chronological application of multiple concepts. We compared the gaze patterns of correct and incorrect problem-solvers when they tackle such tasks. We also analyzed their verbal descriptions of their problem-solving strategies, specifically the concepts and intermediate variables invoked together with how they are used for problem-solving. Our sample was not routinely exposed to sequential synthesis problem-solving. Results indicate that correct and incorrect problem-solvers of sequential synthesis tasks exhibited similar gaze patterns, contrasting with findings from eye tracking studies on single-concept physics problems. This difference may be explained by the characteristics of the sample and the tasks. Unlike our work, participants in previous studies were frequently exposed to comparable tasks in their physics course prior to the study. Earlier eye tracking studies of physics problem-solving have predominantly utilized close-ended conceptual tasks which can often be solved by direct application of (prior) knowledge and common naïve conceptions. For our study, we used open-ended quantitative problems characterized by the connections between multiple events and concepts to create a problem-solving strategy for an entirely new situation. Such problems are more complex and require in-depth understanding and application of key concepts.

Strand 7: Pre-service Science Teacher Education

A model of Two-Eyed Seeing in science education developed with teacher students through action research

Albert Zeyer*, University of Teacher Education Lucerne, Switzerland

ABSTRACT

The analysis of the last twenty years' publications in Science Education found two topics of high prevalence called Argumentation and Scientific practices and Identities and Discourse Analysis. They are both seminal for science education but difficult to balance in the science class room. The presented research uses the kinship of Sellars' stereoscopic view and Indigenous Two-Eyed Seeing for an educational model that can structure preparation, realization, and assessment of science teaching units. The model was tested in science teacher education and refined by a process of participative action research together with future science teachers. The refined model is presented and discussed. It is concluded that its use in science teaching may indeed support the balance between the two complementary topics and that the model, by its very structure and DNA, may help avoiding scientism, promoting scientific literacy, and addressing concerns of equity and inclusion in issues of science education.

Strand 7: Pre-service Science Teacher Education

Pre-service Primary teachers' training through Model-Based Inquiry: What do they perceive to feel and learn?

Manuela González-Herrera*, Universidad de Almería, Spain
María Martínez-Chico, Universidad de Almería, Spain
Francisco José Castillo-Hernández, Universidad de Almería, Spain

ABSTRACT

The need to promote scientific practices in primary schools means that teacher education has to focus on overcoming obstacles to incorporate them into teachers' future instruction. A determining issue in order to overcome such obstacles is the affective aspect. However, and despite the proven critical role that emotions play in learning and teaching processes and outcomes, the emotions experienced when they are learning and their relation with each scientific practice have seldom been considered. In this study, the emotions Pre-service Primary teachers feel and their learning perceptions when scientific practices are experienced is explored. The analysis of the data showed that the majority of the participants: perceived that they developed adequate understandings about scientific practices; experienced concentration and interest throughout their engagement in the teaching and learning sequence. However, other findings about the insecurity felt at certain key moments were reported. These findings are discussed alongside implications for teacher preparation and future research in the field of scientific practices and emotions.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Using digital platforms to assist with teaching and learning during COVID-19 lockdown in South Africa

Magdeline Stephen*, University of the Wiwatersrand, South Africa
Nomfundo Radebe, University of the Wiwatersrand, South Africa

ABSTRACT

Prior lockdown the South African government has attempted to embrace the idea of utilizing digital platforms in teaching and learning. The use of digital platforms assisted all schools to continue with teaching and learning during lockdown caused by COVID-19 pandemic in 2020 and lending these with contact classes in 2021 as contact time was reduced. The connectivism theory was used to guide data collection, in explaining available programs that were available prior lockdown and those that were introduced during lockdown saved the school year in 2020. A document study was used to collect and analyses data qualitatively, using literature from published articles and other documents to assist teaching and learning of Physical teaching and learning during these two years. Findings indicated that intervention strategies with digital platforms assisted in ensuring that teaching and learning of Physical Science, although challenges with availability of resources and access of internet in some rural schools still persist.

Multistrand Related Paper Set

Beyond Absolutes: Expanding Conceptions of Science and Teaching with Preservice Science Teachers

4/28/23, 10:45-12:00, Zoom A

Strand 7: Pre-service Science Teacher Education

Examining Opportunities for Expansiveness in a PST Science Modeling Course

Jessica Watkins*, Vanderbilt University, USA
Natalie De Lucca, Vanderbilt University, USA
Serena Pao, Metro Nashville Public Schools, USA

ABSTRACT

Preservice science teachers often experience classroom science as a seemingly acultural, apolitical, individualistic, and competitive endeavor. For secondary science, preservice teachers take numerous undergraduate science courses that are isolating, overly focused, and racialized, classed, and gendered (McGee, 2020). Given these narrow scientific experiences, we have been designing a Science Modeling course for secondary science PSTs to support a more expansive form of science learning that can help them re-imagine their future science teaching. The goal of this paper is to examine pivotal classroom interactions to understand how opportunities for expansiveness in science learning emerge, get taken up, or get shut down. These examples add to a growing body of literature expanding what counts as knowledge and knowing in science learning environments, showing how expansiveness is

realized (or not) in interactions among PSTs. These episodes also show the pedagogical complexities in responding to sociohistorical power dynamics in creating more expansive science learning environments and invite questions on how to make those complexities salient to both teachers and teacher educators. Lastly, this paper motivates deeper consideration into the content preparation of teachers so that they can foster more expansive and affirming students learning environments for their students.

Strand 7: Pre-service Science Teacher Education

Expanding Pre-service Teachers' Conceptions of Science, Learning, and Teaching

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

ABSTRACT

Dominant views of both science and teaching have focused on narrow absolutes – "best practices," "the canonical answer," and seeking objective, singular truths or standards. These absolutes are limiting for the spaces we can create for learning and for the people within those spaces. The emphasis on absolute singular answers, standards, and practices have a racialized, gendered, and classed history in development of science as a discipline (Mutegi, 2011) and in the development of teaching as a profession (D'Amico Pawlewicz, 2020). This related paper set explores ways of disrupting these "absolutes" with preservice science teachers, by bringing together scholars that are considering teacher education in this juxtaposition of resisting narrow absolutes in both science and teaching, working to open up space for what science teaching and learning can be in classrooms. Each of the four papers center justice-oriented perspectives that consider how social, cultural, and political factors, including race, class, gender, and language, play into what is seen as valuable in science and in teaching. Together, the papers provide insight into and invite conversations around resisting absolutes in teacher education, towards cultivating more expansive conceptions and practices of science and teaching.

Strand 7: Pre-service Science Teacher Education

Examining Opportunities for Expansiveness in a PST Science Modeling Course

Déana Scipio*, IslandWood, USA
Priya Pugh, IslandWood, USA

ABSTRACT

Dominant views of both science and teaching have focused on narrow absolutes – "best practices," "the canonical answer," and seeking objective, singular truths or standards. These absolutes are limiting for the spaces we can create for learning and for the people within those spaces. The emphasis on absolute singular answers, standards, and practices have a racialized, gendered, and classed history in development of science as a discipline (Mutegi, 2011) and in the development of teaching as a profession (D'Amico Pawlewicz, 2020). This related paper set explores ways of disrupting these "absolutes" with preservice science teachers, by bringing together scholars that are considering teacher education in this juxtaposition of resisting narrow absolutes in both science and teaching, working to open up

space for what science teaching and learning can be in classrooms. Each of the four papers center justice-oriented perspectives that consider how social, cultural, and political factors, including race, class, gender, and language, play into what is seen as valuable in science and in teaching. Together, the papers provide insight into and invite conversations around resisting absolutes in teacher education, towards cultivating more expansive conceptions and practices of science and teaching.

Strand 10: Curriculum and Assessment

Chemistry Teachers' Knowledge of Assessment in a Collaborative and Dynamic Learning Environment

Abir Saleh*, Technion, Israel
Shirly Avargil, Technion, Israel

ABSTRACT
There are few opportunities for teachers to hear their students think out loud, and when they do, they often miss the chance to capture learning moments and enact Formative Assessment (FA). In this study, we use the framework of teachers' professional noticing to examine teachers` FA knowledge. This research aims to explore chemistry teachers' FA knowledge and approaches in a collaborative dynamic learning environment. The research questions are: (1) What do chemistry teachers notice as important to assess while observing their students? (2) What characterizes chemistry teachers' interpretation of their noticing? In this study, 15 leading high school chemistry teachers participated in a PD (Professional Development) program. A qualitative approach is employed. Observation worksheets were collected from chemistry teachers during the PD program. Three noticing dimensions were identified: Chemical thinking noticing, 21st century skills noticing, and Affective noticing. Furthermore, we found that: strategy of problem solving, teamwork and cooperation, and identifying topics in the chemistry curriculum that the student is using successfully or incorrectly, are the common characteristics of chemistry teachers' interpretation. Our study aims to promote theoretical knowledge about FA and assessment knowledge through teachers' professional noticing.

Multistrand Paper Set: STEM and Identity
4/28/23, 10:45-11:45, Zoom B

Strand 11: Cultural, Social, and Gender Issues

Taking Up a Theoretical Framework to Support Student/Teacher STEM Identities

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Katie Wade-Jaimes, University of Nevada - Las Vegas, USA
Heidi Carlone, Vanderbilt University, USA

ABSTRACT
Theoretical frameworks are commonly used in research as ways to contextualize, situate, and analyze work. Less commonly used ways to incorporate theory with practice; however, include grounding teacher professional development in a theoretical framework that is also presented as a tool for teachers. This paper uses an identity framework to demonstrate the

interconnections between student and teacher identity within the context of urban education. While this theoretical identity framework grounds the research analysis, it is also used as the design tool for a STEM identity professional development and engaged in with teachers. In this work we explore what is possible when teachers are given an identity framework to explore their own STEM teacher identities and to plan lessons in ways that support their students' STEM identities in their classrooms. Our research question is: How might teachers take up a theoretical framework in their practice? In this paper we present two cases that show the different ways teachers "took up" the framework in their classrooms by analyzing and reflecting on their own teacher identity as well as planning classroom activities to support students' science identities.

Strand 7: Pre-service Science Teacher Education

The middle of the STEM sandwich: Investigating, modeling, analyzing, arguing, and explaining

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Mark Brenneman, Auburn University, USA

ABSTRACT

Thinking like a scientist starts with noticing that we are surrounded by science in our lives. In this study, we investigated whether paying close attention to everyday science and journaling about it, helped preservice science teachers (PSTs) notice everyday science concepts and practices. The PSTs this study kept a science journal for the course of one semester and documented the scientific ideas, questions, observations, inferences, and investigations they encountered in their daily lives. We then looked for evidence of scientific and engineering practices in their journals (NRC, 2012). Participants mostly wrote about two practices: asking questions, and obtaining and communicating information, with 38% of their entries in each category. These practices are the bookends to the scientific enterprise, with the other practices filling in the middle. Scientists and engineers often start with a question and conclude with a publication. The work in the middle of these two practices is the "meat" in the sandwich of STEM. This middle section accounted for only 23% of the entire data set. An implication for using science notebooks would be to suggest more exercises and investigations that could be done at home that are about explaining, modeling, investigating, arguing, or analyzing and interpreting data.

Poster Session
4/28/23, 12:15-13:00, Zoom A

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

The Impact of STEM Curriculum on Students' Abilities of Engineering Design and Attitudes Toward STEM

Meng-Fei Cheng*, National Changhua University of Education, Taiwan
Yu-Heng Lo, National Changhua University of Education, Taiwan

ABSTRACT
This study aimed to design and propose an innovative STEM curriculum that emphasized interdisciplinary teaching not only to better integrate different disciplines and cultivate inquiry and problem-solving abilities but also to enhance students' attitudes toward STEM. To enhance interdisciplinary learning in the STEM curriculum, students were scaffolded to involve relevant scientific and engineering knowledge and employ mathematics to collect and analyze data in their engineering practice when designing their technology products. The participants included 50 tenth-grade students. The research instruments included the assessment of the progression of students' engineering designs in students' journals and a student attitude survey about science, technology, engineering, and the learning environment using pre- and post-tests. The results reveal that due to continuous encouragement to involve interdisciplinary thinking emphasizing science and engineering knowledge in their engineering design processes, students gradually improve their ability to design engineering models. Students also significantly enhanced their attitudes toward STEM and the learning environment compared to the general curriculum in school. This study contributes to a way to encourage interdisciplinary thinking in students' engineering processes and to an assessment to evaluate students' learning progression and results.

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

Analysis of Graduate Physics and Astronomy Programs

Andria Schwortz*, Quinsigamond Community College, USA
Andrea Burrows, University of Central Florida, USA
Adam Myers, University of Wyoming, USA
Daniel Dale, University of Wyoming, USA

ABSTRACT
This work attempts to characterize PhD-granting programs in physics and astronomy in the USA, including their requirements for admissions, candidacy, and graduation. These will be compared to recommendations from professional organizations in the field (such as the American Association of Physics Teachers, American Astronomical Society, and American Physical Society). In addition, they will be evaluated with a critical theory lens for structural barriers to minoritized students, and to determine support structures in place. Preliminary work has been performed on a subset of programs which allow graduate students to submit dissertations on physics and astronomy education research (PER/AER), and descriptions of

these programs are included in this proposal. The final conference paper will include more data from non-PER/AER programs.

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

Exploring Epistemic Performance in Different Task Contexts

Alp Köksal*, Bo_aziçi University, Turkey
Fatih Mercan, Bo_aziçi University, Turkey

ABSTRACT
In this research epistemic performance in different task contexts has been studied. Those contexts were presented as issues. There were two issues in the study. Participants were two physics professors, four preservice physics teachers and four social sciences students. Apt-AIR framework has been adopted in the study. As data collection, think aloud protocol and semi-structured interviews were used. Results of the study showed that Apt-AIR framework can be used for capturing and modelling epistemic performance in different task contexts. Physics professors have demonstrated wide range of aspects of epistemic performance. Furthermore they have transferred their epistemic competence to an area outside of the expertise. Social sciences students have understood the social aspects of the second issue and adapted their epistemic performance accordingly. However, teaching physics students haven't transferred any aspects of apt epistemic performance from their prospective field to the second issue. In the second issue, regardless of background, each member of the society has to take point of view. In light of the findings, there is a need to increase the awareness of teaching physics students on adjusting their epistemic performance while engaging in such issues.

Strand 6: Science Learning in Informal Contexts

STEM interest patterns during adolescence: A latent profile analysis

Nancy Staus*, Oregon State University, USA
Lynn Dierking, Institute for Learning Innovation, USA
John Falk, Institute for Learning Innovation, USA

ABSTRACT
To better understand age-related STEM interest patterns during adolescence, we examined STEM interest profiles and how they changed over time for three cohorts of youth over three years (grades 6 through 8) in an urban low-income community. We used a survey to measure interest in four components of STEM, used latent profile analysis to classify youth based on STEM interest, examined how the profile structure changed over time and investigated how demographic and interest-related factors (e.g., science attitudes) varied across profile membership. Three STEM interest profiles emerged in sixth and seventh grade: STEM interested, STEM neutral and STEM disinterested with no gender differences across profiles. In eighth grade a fourth profile emerged: technology/engineering/math disinterested comprising 11% of youth, mostly girls. There were no differences based on race/ethnicity. Although proportions of youth in the STEM neutral and STEM disinterested profile remained similar over time, those in the STEM interested profile decreased from sixth grade to eighth grade. Positive science attitude, feelings that science was relevant, parental support, and participation in out-

of-school STEM activities were strongly associated with the STEM interested profile. Results suggest that seventh grade may be a critical intervention point in STEM interest persistence.

Strand 7: Pre-service Science Teacher Education

Physics Experiences of Elementary Teacher Candidates for Empowerment: A Case Study Survey Design

E.J. Bahng*, Iowa State University, USA
John Hauptman, Iowa State University, USA

ABSTRACT

The need for elementary teacher candidates (ETCs) to be equipped with authentic physics experiences for their empowerment has become critical for the advancement of national STEM education. We have developed a tailored physics course, entitled PHYS 102L, that embodied experiential, hands-on physics activities that were grounded in physics core ideas from Next Generation Science Standards together with the Communities of Practice approach, reciprocal peer teaching, and video-mediated learning. This case study survey research involved a cohort of 143 ETCs (134 Females and 9 males) in order to explore the essence of the physics experiences before and after taking PHYS 102L. Findings indicated that the cohort of ETCs entered PHYS 102L with minimal learning experience and no physics teaching experience. The ETCs had been taught physics mostly through textbooks and worksheets with insufficient teacher facilitations and relied on memorization of facts for tests. Consequently, they rarely believed that they were confident enough to learn and teach physics. After the PHYS 102L semester, however, two-thirds of the ETCs found themselves having had meaningful physics learning and teaching experiences. Finally, the ETCs listed both the consistent exposure to hands-on physics experiments and the collaborative and dialogical physics videos as impactful elements.

Strand 10: Curriculum and Assessment

The alchemy of university-school relations through an experience of Brazil's initial Biology teacher training

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Gabriel Pedro*, Universidade Federal do Rio de Janeiro, Brazil
Marcia Ferreira, Universidade Federal do Rio de Janeiro, Brazil

ABSTRACT

This paper focuses on discursive productions of university-school relations through an extension project conducted by a public university in the southeast region of Brazil, with effects on initial training of Biological Sciences teachers. The investigation, mobilizing Thomas Popkewitz's notion of 'alchemy of school subjects', was carried out in a historical perspective, part of a 'discursive approach' to the History of the Curriculum as the History of the Present. In it, we assembled a research archive of public policies and academic papers that address the university-school relationship in the training of Biological Sciences teachers, and how this relationship occurs in this specific extension project. We were able to elaborate that the university-school relationship, as a discursive object constructed in the Brazilian context, is characterized as binary and, sometimes, antagonistic; it was possible to say, from our

exploratory analysis, that are part of the project's alchemical processes: the production of teaching materials, the planning and development of workshops and experimental activities. Thinking about such alchemical practices represent the potential to imagine the relationship university-school not as directed interactions between two foreign objects, but as malleable sets of experiences in which, simultaneously, teachers and school knowledge are formed and form themselves.

Strand 11: Cultural, Social, and Gender Issues

Discourse around Creationism in an evolution textbook: A critical discourse analysis

Andrea Phillips*, Indiana University, USA

ABSTRACT

This study presents a critical discourse analysis, with the analysis focus of the discourse around Creationism in an evolution textbook. Analytic questions include how the discourse in the textbook functions to delegitimize religion as an epistemology, and how the discourse functions to position religious individuals. Analysis was guided by Fairclough's three dimensions, examining textual, discursive, and social functions of the textbook. Findings show that the discourse delegitimizes religious ways of knowing by their use of court cases, use of quotes around words to call into question religious claims and ideas, and positioning religious ideas as easily discounted or understandably ignored. Additionally, the discourse serves to position religious individuals as homogeneous, with all having the same beliefs and views, views different from scientists. The text also positions religious individuals as relying on trickery. Recommendations are made for facilitating acceptance of evolution and reconciliation of beliefs among religious students, and aiding in their development of a science identity.

Strand 15: Policy, Reform, and Program Evaluation

Why NOT Become a Teacher? Perspectives from Undergraduate Students

Jacob Pleasants*, University of Oklahoma, USA

ABSTRACT

Recruitment of teachers is a perennial concern in the United States as well as countries around the world. Addressing the issue of recruitment requires attending to prospective students' interests, motivations, and perceptions of the teaching profession – topics that have been the subject of decades of research work. That research points to key motivations as well as sources that influence those motivations, but a significant limitation is that most of this work has focused only on individuals who have already chosen to become teachers. Mostly absent are perspectives from individuals who are not planning to teach, but could potentially be convinced to do so; in other words, the potential recruitment pool. The goal of the present study was to address this gap by investigating views of the teaching profession held by a general population of first-year undergraduate students. Students' views were gathered via an anonymous online survey. Our findings indicate that many students have not ruled out teaching as a career, and that those students perceive teaching to be rewarding and fulfilling. However, they also hold negative perceptions related to pay and working conditions that dissuade them from choosing to pursue teaching.

Concurrent Session 4

4/28/23, 14:00-15:00

Multistrand Paper Set: Creating Connections in Science Teaching and Learning
4/28/23, 14:00-15:00, Zoom A

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

Epistemic belief and science career expectancy in China: Using PISA data to understand gender differences

Xuerong Lin*, East China Normal University, China

ABSTRACT

Based on PISA2015 data of B-S-J-G(China), this study aims to assess the relationship among 15-year-old Chinese students' epistemic beliefs, self-efficacy, motivations, academic achievements and career expectancies in science across genders. Results from the structural equation modeling showed that students' epistemic beliefs had direct impact on self-efficacy, motivations and achievements. Epistemic beliefs also indirectly affected students' career expectancies through mediating variables such as self-efficacy, motivation structures and academic achievement. These findings were consistent across genders. Compared with male model, female model was not fit as expected. Academic achievement and career expectancies were less affected by the intrinsic motivation of female students. A combination of social economic status and self-regulated learning structures across genders may provide valuable insights to future research.

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

Retaining Students from Minoritized Groups in STEM Majors: The Role of Counterspaces and Distributed Mentoring

Stacy Olitsky*, Saint Joseph's University, USA

ABSTRACT

Retention within STEM majors is related to whether the student has developed a sense of community, identity and self-efficacy associated with the field. Yet studies have found that identity development in STEM can be obstructed for students from minoritized backgrounds due to issues such as views of STEM as objective, distant and non-communal. It is possible that effective mentoring and research relationships could serve as counterspaces for STEM majors from minoritized groups. However, mentoring may not necessarily lead to equity-focused reform within STEM departments. This qualitative study focuses on a mentoring program for students from minoritized backgrounds, investigating impacts on identity and retention, and implications for either reaffirming or subverting the alienating aspects of university-level STEM. Findings indicate benefits of structured opportunities for informal interactions with faculty members, a focus on diversity, acknowledgement of the "backstage" processes of changing paths and making mistakes, access to multiple networks, and distributed mentoring approaches. The results suggest the benefits of programs that extend beyond a mentoring dyad which can help with acclimation, and instead emphasize a climate of

collaboration and distributed mentoring that can foster the development of counterspaces and subvert views of STEM as competitive and individualistic.

Strand 7: Pre-service Science Teacher Education

Looking for science: Preservice science teachers journaling about science in daily life

Danielle Hudson*, Auburn University, USA
Christine Schnittka, Auburn University, USA

ABSTRACT

For decades now, schools around the world have been focused on increasing the scientific literacy of youth. To better prepare teachers, teacher education programs have the goal to engage pre-service teachers (PSTs) in meaningful science education curriculum that will translate into science being taught in a better way. In this study, pre-service teachers in their second science methods class were challenged to keep a science journal and write about the science that they saw in their everyday lives. The goal was to help PSTs see connections between school science and everyday life. The authors of this paper were interested in the science content that the PSTs would write about and what would motivate them to continue writing about science. The participants were encouraged to write 15 entries each month and the entries were graded by the second author of this paper. The study determined that PSTs teachers wrote primarily about biological science (26%), followed by chemistry (16%) and astronomy (10%). Regardless of content background, the dominant category was biology. Implications for future lessons are discussed.

Strand 11: Cultural, Social, and Gender Issues

Bridging Science and Language: Responsive Curricula for Refugee Multilingual Learners

Rena Al Debs*, University of Balamand, Lebanon
Sara Salloum, University of Balamand, Lebanon

ABSTRACT

The language demands of sciences are different from everyday language, with more research highlighting the significance of students developing science's subject-specific language for enhanced learning and understanding. Yet the language demands of science can be especially challenging to multilingual learners, and with migration and globalization making science classrooms more linguistically diverse, it is crucial that we provide multilingual students with quality science education that leverages their diverse linguistic and cultural resources, emphasizes their contribution to knowledge-building, and engages them actively in disciplinary language. A growing special group of multilingual learners around the world is refugees displaced due to hardships and war. We investigated the experiences of Grade 7 Syrian refugees in Lebanon with a linguistically responsive science curriculum that draws on: dialogism and bridging everyday ways of knowing with scientific knowledge and language, multilingualism as a resource and translanguaging, and purposeful conceptual and language scaffolds. Our research design combined a qualitative case study with youth participatory action research; for this paper, we report on video recording data. Our findings outline language practices and underscore the importance of dialogic teaching that incorporates

active multimodal activities and purposeful translanguaging for supporting diverse multilingual students' meaning-making and development of scientific language.

Multistrand Paper Set: Integrating Engineering and Science
4/28/23, 14:00-15:00, Zoom B

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

Assessing Elementary Teachers' Nature of Engineering Views via Open-Ended Views of Nature of Engineering Instrument

Erdogan Kaya*, George Mason University, USA
Ezgi Yesilyurt, Weber State University, USA
Hasan Deniz*, University of Nevada Las Vegas, USA

ABSTRACT
The purpose of this study was to assess elementary teachers' Nature of Engineering (NOE) views in order to address the following research question: To what extent do elementary teachers' NOE understandings align with the NOE conceptual framework? The study utilized the valid and reliable Views of Nature of Engineering – Version B (VNOE-B) instrument to assess NOE understanding among teachers. The study found that teachers held similar NOE beliefs and that their understanding of NOE aspects was limited and rather naïve. These findings suggest that pre- and in-service teachers tend to hold incomplete NOE views and that there is a need for training to equip them with the knowledge and skills required to teach the epistemology of engineering effectively. Therefore, the findings of this study will be of great interest to teacher educators who are seeking ways to help teachers better understand NOE.

Strand 8: In-service Science Teacher Education

A Systematic Review of Engineering Design for Authentic Integrated Science and Engineering Instruction: 1997-2021

Sandra Richy John*, Southern Illinois University Carbondale, USA
Senetta Bancroft, Southern Illinois University Carbondale, USA
Cody Maze, Southern Illinois University Carbondale, USA

ABSTRACT
The current National Science Teaching Association and Association for Science Teacher Education content pedagogy standard calls for science teachers to be able to use engineering practices in support of science learning. The Next Generation Science Standards emphasize engineering design in K-12 education for developing 21st century skills for career readiness and promoting scientific literacy. However, in-service teachers and science education faculty implementing teacher professional development programs alike may find it difficult to authentically integrate the standards relevant to their practice as they are likely untrained in using engineering to support science instruction. From the existing body of literature, we conducted a systematic literature review aimed at identifying effective strategies for authentic integration of science and engineering in professional development programs. Our systematic literature review analyzed peer-reviewed articles incorporating engineering design in K-12

teacher professional development for integrated science and engineering instruction in the United States between 1997 and 2021. We present our preliminary findings and discuss strategies that work, challenges teachers still face in implementing engineering design with fidelity after professional development, and implications.

Strand 7: Pre-service Science Teacher Education

Middle and High School Pre-service Science Teachers' Engineering Design Self-Efficacy

John Ojeogwu*, University of Virginia, USA
Frackson Mumba, University of Virginia, USA

ABSTRACT

This study investigated the changes in and sustainability of the self-efficacy of middle and high school pre-service teachers (PSTs) to teach science using engineering design after intervention in science methods course and after teaching the engineering design integrated science (EDIS) lessons in schools. The intervention was designed to develop a sound understanding of engineering design and skills for developing EDIS lessons. Pre-service teachers created EDIS lessons and implemented them in schools during their student teaching. Data was collected using the Teaching Engineering Self-Efficacy Scale (TESS) survey with a pre-test before the intervention, a post-intervention, and a post-implementation of EDIS lessons in schools. Results indicate that PSTs' self-efficacy increased significantly across all factors assessed after the intervention in the science methods course. Post-implementation results suggest that general engineering design self-efficacy remained stable, but the engagement and disciplinary factors did change significantly after classroom implementation. The PSTs' self-efficacy for EDIS teaching improved substantially from pre-test to post-implementation. The implications of these results and areas of future research are discussed.

Strand 7: Pre-service Science Teacher Education

Linear Growth Model Analysis of Pre-service Science Teachers' Self-Efficacy.

Frackson Mumba, University of Virginia, USA
John Ojeogwu*, University of Virginia, USA

ABSTRACT

This research examined changes in the self-efficacy of middle and high school pre-service teachers (PSTs) to teach science using engineering design after intervention in a science methods course and delivering engineering design integrated science (EDIS) courses in schools. Multilevel linear growth models were used to examine the data. The objective of the intervention was to foster a solid knowledge of engineering design and the development of engineering design-integrated scientific curricula. During their student teaching, PSTs developed EDIS lessons and enacted them in schools. Using the Teaching Engineering Self-Efficacy Scale (TESS) survey, data were gathered prior to the intervention, after the intervention, and after the implementation of EDIS classes in schools. The results demonstrate that the PSTs had varying degrees of self-efficacy before the intervention. Controlling for pertinent covariables, further analysis reveals that the self-efficacy of the PSTs increased significantly over time for each factor evaluated.

Concurrent Session 5

4/28/23, 15:15-16:15

Multistrand Paper Set: Pedagogical Innovations in Science Education

4/28/23, 15:15-16:15, Zoom A

Strand 7: Pre-service Science Teacher Education

Preparing preservice science teachers to enact scientific modeling-based instruction: A literature review on existing interventions

Kennedy Chan*, The University of Hong Kong, Hong Kong
David Lau*, The University of Hong Kong, Hong Kong

ABSTRACT

The purpose of this systematic literature review is two-fold: (1) to identify design features used in existing interventions for developing preservice science teachers' (PSTs') teacher competence for teaching scientific model and modeling; and (2) to synthesize evidence of their effectiveness. A systematic database search identified 18 articles reporting interventions in nine countries. The interventions were analyzed to identify their design features, the precise aspects of teacher competence targeted, the data sources used to measure the teacher competence, and their outcomes. The findings revealed that although all the interventions engaged PSTs in modeling instruction as learners, the modeling experiences provided to PSTs differed in terms of their duration, frequency, authenticity, use of contexts, and provision of computer modeling tools. While some interventions targeted the development of PSTs' modeling competence, others also developed PSTs' pedagogy for modeling instruction alongside in their interventions. Importantly, the majority of the interventions targeting declarative aspects of teacher competence reported positive outcomes, while most of those targeting enacted knowledge (e.g., applied in teaching tasks or in classroom practices) and affective–motivational aspects of teacher competence reported mixed outcomes. We provide recommendations for the design and implementation of interventions that may better support PSTs' enactment of modeling instruction.

Strand 7: Pre-service Science Teacher Education

The Science Practice of Asking Questions About Phenomena: Shifting Towards Generating Explanatory Questions

Jaclyn Murray*, Augusta University, USA

ABSTRACT

To center the science practices and make coherent the science experiences of prospective elementary teachers in an undergraduate elementary education program, we implemented a model-based inquiry approach across the physical science for elementary teachers and elementary science education methods courses. Prospective elementary teachers constructed scientifically oriented questions as science learners in the physical science course when presented with a phenomenon that would guide a set of investigations and the development of a visual model and written explanation to describe how or why the phenomenon occurred. The

proposed presentation focuses on the questions prospective elementary teachers ask, throughout the semester, upon observing five different phenomena for the first time.

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

Development and Initial Validation of the Quantitative Modeling Observation Protocol (QMOP) for Undergraduate Biology Courses

Lyrica Lucas*, University of Nebraska-Lincoln, USA
Anum Khushal*, University of Nebraska-Lincoln, USA
Joseph Dauer, University of Nebraska-Lincoln, USA
Brian Couch, University of Nebraska-Lincoln, USA
Robert Mayes, Georgia Southern University, USA

ABSTRACT

Educational reform priorities such as emphasis on quantitative modeling (QM) have positioned undergraduate biology instructors as designers of QM experiences to engage students in authentic science practices that support the development of data-driven and evidence-based reasoning. Yet, little is known about how biology instructors adapt to the pedagogical movement toward incorporating QM opportunities for students in the courses they teach. This study presents the development of the Quantitative Modeling Observation Protocol (QMOP), a classroom observation instrument designed to support the need for research to characterize the current landscape of QM instruction in undergraduate biology. The QMOP is designed to provide information about the breadth and depth of QM implementation across three hypothesized dimensions – authentic instruction, teaching for understanding, and quantitative approach to teaching biology. We present an interpretive argument in relation to the intended use of the instrument and present evidence to assess the validity of our assumptions and inferences about observation scores generated using the instrument. Strengths and weaknesses of evidence pertaining to assumptions about scoring, generalizability, extrapolation, and implications will be discussed to build a validity argument for observations and demonstrate how the instrument can be used for investigating QM instruction in undergraduate biology.

Multistrand Paper Set: The Power of Relationships in Science
4/28/23, 15:15-16:15, Zoom B

Strand 6: Science Learning in Informal Contexts

Relationships with pets as a context for science learning

Priyanka Parekh*, University of Colorado Boulder, USA
Joseph Polman, University of Colorado Boulder, USA
Shaun Kane, University of Colorado Boulder, USA
Ben Shapiro, University of Colorado Boulder, USA

ABSTRACT
Pets are valued family members in many cultures. The close, long-term association between human youth and pets could be a productive setting for combining perspective-taking and science learning. Drawing on the ideas of natureculture and pets as companion species (Haraway, 2003), we studied high schoolers learning science at a virtual summer workshop situated in the close relationship between humans and pets. We encouraged teens to inquire into their pets' sensory experiences at home, using science learning practices and two Augmented Reality (AR) Snapchat filter tools, DoggyVision and KittyVision, designed to mimic canine and feline selective color vision and visual acuity. In this paper, we report one teen participant's efforts to understand her dog's interest in watching television, specifically, how the teen participant engaged in constructing explanations and arguments about the canine companion's experiences situated in their everyday life. We found that the participant was attentive to several ecological and relational factors as she explained and argued her dog's response to events at home. We conclude that close personal relationships with pets and AR tools facilitating perspective-taking can facilitate rich, meaningful science learning for youth.

Strand 6: Science Learning in Informal Contexts

Networks and Ecosystems: Plant/Gardening Enthusiasts' Use of Community Spaces to Support their Learning

Elysa Corin*, Institute for Learning Innovation, USA
Eric Jones, University of Texas Health Science Center at Houston (UTHealth) School of Public Health, USA
David Meier, Institute for Learning Innovation, USA

ABSTRACT
This study adds to the conversation about the community-based STEM learning ecosystem, using innovative network research methodologies to identify which places adult free-choice learners access to pursue a specific STEM-related interest (gardening), and what works for whom. Data from a sample adult plant/gardening hobbyists who live in the same community are shared, focusing on the extent to which they draw on eighteen types of community spaces (e.g., botanical garden, museum, plant nursery, park, grocery store) while engaging in their plant and gardening interest. Results examine the relationship between participants' demographic characteristics, science identity, and a plant/garden identity and the learning environments participants choose to engage with. Logistical regression models and network models were developed.

Strand 11: Cultural, Social, and Gender Issues

Equity in rural physics education: Voices of a student, a teacher, and an immigrant parent

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

ABSTRACT
Many students are unable to relate physics to their lives because physics has often been decontextualized from their experiences, especially rural students. However, parents of the

students can influence their children's learning. Unfortunately, parents were rarely included as research participants. Besides, the use of FOK was uncommon in physics education research. This study aims to uncover the perspectives of a student, a teacher, and an immigrant parent regarding physics education. A case study was adopted with an interpretive paradigm. This study was conducted in the poorest state in Malaysia, Sabah in 2021. The methods used to collect data were interviews, document collections, and home visits. All data were analyzed thematically using a constant comparative method. Shared perspectives across the three parties (student, teacher, parent) were focused because they were stronger in terms of data triangulation. The main finding is that all three parties (student, teacher, parent) trust each other for better physics teaching and learning. The student and her parent believed that physics could be the tool to get a better job and escape from poverty. In conclusion, being a functional society member is key for the rural student to make changes in her life using physics education.

Strand 14: Environmental Education and Sustainability

Navigating Relational Perspectives through Collaboration to Expand Students' Experiences of/with/in Places and Cultures

Beth Covitt*, University of Montana, USA
Nicollette Frank, University of Montana, USA
Noelani Puniwai, University of Hawai'i, USA
Ho'oulul_hui Perry, University of Hawai`i, USA
Bruce Watson, University of Hawai`i, USA
Sarah Haavind, Concord Consortium, USA
Dale Cope, Independent Education Consultant, USA
Carolyn Staudt, Concord Consortium, USA

ABSTRACT

Making sense of what to do about the many daunting environmental issues that we face will require intercultural understanding, openness to learning, and a capacity to draw on the strengths of multiple perspectives and to recognize limitations of dominant perspectives such as Western science. Navigating multiple perspectives in school science can be particularly treacherous for Indigenous students, whose cultural worldviews have often been excluded or denigrated in Western educational contexts. We present findings from our partnership project that is designing, implementing, and studying instructional experiences for middle school students from significantly/predominantly Indigenous communities in Alaska and Hawai'i. This paper describes our early efforts to understand project partners' standpoints, acknowledging that in designing and implementing multi-perspective middle school science instruction, it will be critical to understand the multiple perspectives that we ourselves bring to the work. We present and discuss the views that project partners (including teachers) have shared concerning science, science education, multiple perspectives, and Indigenous cultural integrity; similarities and differences among partners' views; and potential consequentiality for our project's collaborative work. Three prominent themes relate to relationships with place, relationships between worldviews, and individuals' multi-faceted relationships with one another and the world.

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