NARST

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PORTLAND, OR, USA

Portland Marriott
Downtown Waterfront

CITIZENSHIP • COMMUNITY • SCHOOL

SCIENCE EDUCATION ACROSS PLACES AND CONTEXTS

3/15/20

Concurrent Session 1
2:40 PM-4:10 PM

Equity and Ethics Committee
Admin Symposium-Addressing Issues of Equity and Justice across Places and Context in Science
2:40 PM-4:10 PM, Mt Hood

Organizers
Catherine Quinlan, Howard University
Ying-Ting Chiu, The Ohio State University
María González-Howard, University of Texas at Austin
Stephanie Eldridge, University of Georgia
James M. Nyachwaya, North Dakota State University
Presenters
Christopher Atchison
Sami Kahn, Princeton University
Shari Watkins
Brittany Garvin-Hudson

ABSTRACT
This equity and ethics symposium extends the meaning of accessibility across places and contexts for those marginalized because of gender, ethnicity, Race, medical, economics, and disabilities. This means pushing the margins and boundaries in science to understand what it takes to do science in a wheel chair or what it means to include all the voices of people who have contributed to science. The audience will come away inspired with new understandings and atypical images about where science can happen. This symposium will encourage the audience to think beyond whose science counts and has been privileged. Panel presentations will be followed by interactive discussions and presentations with practical implementation of culturally responsive pedagogy. Topics have implications for what it means to break stereotypes rather than react to disabilities and differences. Issues of equity, social, cultural, historical, and political implications for science learning and practices in higher education and K-12 settings are implicated.

Strand 1: Science Learning, Understanding and Conceptual Change
Learning and Teaching Evolution in High School: Challenges and Possible Remedies
2:40 PM-4:10 PM, Salmon
Discussant: Kostas Kampourakis, University Of Geneva
Presider: Anat Yarden, Weizmann Institute Of Science

High School Students' Types of Teleological Explanations: Implications for Item Development and for Teaching-Learning Strategies
Janina Jördens, Münster University
Marcus Hammann, Münster University

Experiencing the Development of Antibiotics Resistant Bacteria: Students' Understanding of the Nature of Evolution
Bat-Shahar Dorfman, Weizmann Institute of Science
Orna Dahan, Weizmann Institute of Science
Amir Mitchell, University of Massachusetts Medical School
Anat Yarden, Weizmann Institute Of Science

Plant Blindness – What German High School Students and In-Service Biology Teachers
Daniela Fiedler, IPN - Leibniz Institute for Science and Mathematics Education, Kiel, Germany
Isabell Rösberg, IPN - Leibniz Institute for Science and Mathematics Education, Kiel, Germany
Marc Rodemer, IPN – Leibniz Institute for Science and Mathematics Education, Kiel, Germany
Birgit Heyduck, IPN – Leibniz Institute for Science and Mathematics Education, Kiel, Germany
Ute Harms, Leibniz Institute for Science and Mathematics Education (IPN)

Capturing Instructional Strategies of Pre-Service Biology Teachers to Counter Misconceptions about Evolution by the SCRBio
Julian Fischer, Leibniz Institute for Science and Mathematics Education
Nils Machts, Department of Educational Psychology (IPL), Kiel University
Jens Möller, Department of Educational Psychology (IPL), Kiel University
Ute Harms, Leibniz Institute for Science and Mathematics Education (IPN)
Kostas Kampourakis, University Of Geneva

ABSTRACT
Every citizen should understand the importance of evolution-related subjects that relate to everyday life. Indeed, evolution has been recommended to be integrated throughout the undergraduate biology curriculum, into K-12 science education in the US, and in the curricula of other countries. Nevertheless, numerus misconceptions about evolution were identified among different populations, from middle-school students to college undergraduates and pre-service teachers. In this related-paper-set four leading scholars in the evolution education field will be focusing on the current state-of-the-art of the learning and teaching of evolution in senior high school. From the characterization of high school students' types of teleological explanations, to advancing students' understanding using a novel instructional strategy that enabled to experience bacterial evolution in a test tube, to illuminating new insights into the role of plants in the teaching and learning of evolution, and finally into a novel digital instrument that enables to assess diagnostic knowledge about evolution among pre-service teachers. Taken together, this session will on the one hand bring insights into promoting our understanding of students' and teachers' comprehension difficulties and means to probe them, and on the other hand novel instructional strategies that attempt to promote the understanding of evolution in high school.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Language & Learning Science
2:40 PM-4:10 PM, Hawthorne/Belmont/Laurelhurst
Presider: Katherine Carr Chapman, Vanderbilt University

Hispanic Student Perceptions toward Spanish, Learning Science, and Attitudes
Angela Chapman, University Of Texas Rio Grande Valley
Anthony Bailey, University Of Texas Rio Grande Valley

Amy Weimer, Texas State University
Shania Pintor, University Of Texas Rio Grande Valley
Stephany Pinales, University Of Texas Rio Grande Valley

ABSTRACT
Learning science vocabulary is a challenge for educators and all students. This is especially true for students whose first language is not English. This study investigated student perceptions toward science, Spanish, and learning for Hispanic high school students. We report that students have a more positive attitude toward science than they do toward the role of Spanish and science. In addition, instruction that explicitly connects Spanish to learning has a positive effect on their attitude toward the role of Spanish in learning science.

Languages of Modeling, Modeling in Languages: Integrating Science and Translanguaging
Ashlyn Pierson, Vanderbilt University
Douglas B. Clark, University of Calgary
Corey E. Brady, Vanderbilt University

ABSTRACT
This design-based study adopts a syncretic approach to leverage parallels between emerging bilingual students' everyday translanguaging practices and scientific modeling practices to address goals related to equity and disciplinary learning. The design is grounded in two principles: (1) valuing and promoting modeling-in-languages, including English, Spanish, and invented language, and (2) creating opportunities for students to recognize and analyze the multimodal languages-of-modeling. We find that these principles support emerging bilingual and monolingual students' engagement in negotiated and purpose-driven scientific discourse.

The Effects of Language and Other Home factors on Lebanese Students' Performance in TIMSS
Rayya Younes, University of Balamand
Sara Salloum, University of Balamand
Maya Antoun, University of Balamand

ABSTRACT
The aim of this study is to describe and explore language and other home factors affecting the performance of Lebanese students in TIMSS. In Lebanon, Science and Mathematics are taught in a foreign language based on a language-in-education or Language of Learning and Teaching policy (LoLT) that dates back to 1926. It is suggested that LoLT policies may create 'linguistically structured inequalities' or linguistic discrimination, where poor proficiency in the international language results in poor achievement of learners. Exploring TIMSS data can help us locate areas and groups of students that need more support to counter such inequalities. Using the TIMSS data and hierarchical linear modelling (HLM), we examined the performance of students in Mathematics and Science depending the language of the test, how frequently they spoke it at home, and other home factors: parents' education level, number of books owned, and parents' involvement. Results show that the effect of the frequency of the spoken language at home on the students' performance is affected by the language of the test. Moreover, there is a direct relationship between the parents' education level and the students' performance. We discuss these findings utilizing Bourdieu's notion of cultural capital.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

The Chemistry Learning Environment

2:40 PM-4:10 PM, Meadow Lark/Douglas Fir - 3rd floor

Presider: Jonathon Grooms, George Washington University

Why do students choose a context? Students' reasons for choosing a learning task in chemistry

Helena Van Vorst, University of Cologne
Hatice Aydogmus

ABSTRACT

Context-based learning has gained an increasing influence in science education over the last 30 years. However, it is still unclear which types of contexts foster students' interests and learning achievement and hence, are appropriate for science classes. While contexts are usually selected by the teachers or curriculum developers, this study focusses on students' perspective. The central aim of this research project is to analyze which contexts students choose for their science learning and what are the reasons for their choice. Therefore, a questionnaire study has been conducted. The data analysis illustrates significant differences in the selected contexts depending on students' individual variables like sex or individual interest in the subject. Additionally, a cluster analysis has produced three clusters for describing students' explanation patterns for selecting a specific context. Overall, the results of this study give a deeper insight into possible reasons for differential effects of context-based learning in different studies and allow first conclusions about the question, which types of contexts should be implemented in science classes for specific groups of students.

High School Student's Understanding of Molecular Representations in a Chemistry Context-Based Learning Environment

Ran Piorko, Technion - Israel institute of technology
Shirly Avargil, Technion - Israel Institute of Technology

ABSTRACT

Teaching chemistry should emphasize scientific literacy, high order thinking skills and context-based learning (CBL) as one of the main pedagogical tools. This study concentrates on the effects of CBL environment on student's ability to understand molecular representations, investigates CBL outcomes related to student's gender and chemical understanding abilities. Participants included 370 11th grade chemistry majors that were taught chemistry aspects of fats and lipids. Research groups included experimental group (N=271), and two comparison groups (N=99). The experimental group studied in a CBL environment, the comparison groups studied without CBL environment. We used mixed method to analyze pre / post questionnaires that were given to the students. Findings indicate that when students are taught in a CBL environment their achievements are higher. The experimental group gained highest scores in the post questionnaire and had the highest net-gain of average scores. In the experimental group the average scores and net-gain were the highest for the girls. Data analysis showed that the net-gain of low achievers in the experimental group was significantly higher than medium and high achievers. This research strengthens findings from other researches showing that CBL environment contributes to high level of understanding in chemistry education.

Impact of Earth Science Integration on Student Learning in a High School Chemistry Course

Jonathon Grooms, George Washington University
Kevin J. Fleming, George Washington University
Alan R. Berkowitz, Cary Institute of Ecosystem Studies
Mary Ellen Wolfinger, George Washington University
Bess Caplan, Cary Institute of Ecosystem Studies
Chelsea McClure, Cary Institute of Ecosystem Studies

ABSTRACT
Implementing NGSS has potential effects that necessitate shifts in curriculum, pedagogy, and learning environment. These potential shifts impact teachers, students, and curriculum development efforts. This study investigates the curriculum implementation efforts in a large urban district that, in response to NGSS, has developed an integrated chemistry and Earth science curriculum for their existing high school chemistry courses. The transition from a discipline-specific 10th grade chemistry course to an integrated chemistry and Earth science course, during early stages of system-wide implementation can induce an array of enthusiasm, skepticism, and confusion. Therefore, examining student learning data and teachers' and students' reflections and perceptions from their shared curricular experiences reveals significant student learning gains and highlights student and teacher readiness and reticence for engaging in three-dimensional teaching and learning. Synergies and tensions between teachers' and students' perceptions of the implementation efforts will be described (e.g., espoused versus perceived instructional approaches and coherence of integrated curriculum). Implications for supporting professional learning and sustainable curriculum reform are discussed.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Teacher knowledge, beliefs, & use of science practices with students

2:40 PM-4:10 PM, Medford

Presider: Joi Merritt, James Madison University

An Exploratory Comparative Video-study of Scientific Modeling in Elementary/Primary Classrooms in the U.S. and Germany

Florian Böschl, University of Leipzig
Kim Lange-Schubert, University of Leipzig
Cory T. Forbes, University Of Nebraska–Lincoln

ABSTRACT
At the forefront of science education reform efforts has been an emphasis on incorporating more authentic/meaningful scientific practices into formal learning environments (NGSS 2013, GDSU 2103). With this focus on practices, such as scientific modeling – a powerful tool for sense-making and reasoning –comes a need to observe and understand if/how it is actually occurring, particularly in primary science learning environments (Pianta & Hamre, 2009). Addressing this need, this study presents results of an international observational study in which we use an observation protocol (Author, 2018) to characterize scientific modeling in primary classrooms in both the U.S. and Germany. Drawing on existing video-based datasets from multiple projects, this study's findings provide empirical evidence for model-based teaching/learning and explore the relative frequencies/effectiveness of relevant modeling subpractices. This research also illustrates differences between these trends between German and American classrooms. In general, students in both countries more often experience model construction than other modeling practices. Observed German teachers, however, more consistently

foreground anchoring phenomena, students' questions/preconceptions, thus leading to higher overall modeling scores. Results indicate the need for a greater focus on all scientific modeling subprocesses and the integration of scientific modeling with more general strategies for effective science teaching.

Examining the Relationship between Preschool Teachers' Attitudes and Beliefs towards Science and Children's Science Achievement
Elica B Sharifnia, University of Miami
Alexandra Alexander, University Of Miami
Silvia Niño, University of Miami

ABSTRACT
Despite growing national attention to the importance of science for young children, there is still little research focused on supporting high quality science learning in childhood. Teachers' attitudes and beliefs towards science are one critical factor to explore given the influence they have on classroom practice. Prior research has examined the impact of preschool teachers' attitudes and beliefs on classroom practice around science, however, little research has focused on this relationship to children's understanding of science knowledge. To address this gap, the current study examines the relationship between preschool teachers' attitudes and beliefs towards science specifically related to the following: (1) comfort with science (Teacher Comfort), (2) whether they view science as beneficial for children (Child Benefit), and (3) perceptions of the challenges of supporting children's science learning (Challenges) and their children's science achievement. Twenty-four Head Start teachers and 321 preschool children participated in this study. Results indicated no significant relationships between the factors of Teacher Comfort and Challenges with children's science achievement, yet there was a significant positive relationship between teachers' ratings of the Child Benefit factor and their children's science achievement. Results are discussed in terms of implications for professional development around early science learning.

Ms. Bernina's Knowledge of Her Students' Knowledge and of Science Teaching
Ashley N. Kooken, West Virginia University
Melissa J. Luna, West Virginia University

ABSTRACT
Research on elementary science education argues that teachers must attend to their students' everyday ideas for meaningful learning to occur (National Research Council [NRC], 2007, 2012). But in order to attend to students' everyday ideas, teachers must first know something about their students' ideas related to the scientific phenomenon under investigation; therefore, it is important that teachers elicit their students' ideas not only while they teach science but also prior to instruction so they can plan science lessons informed by their students' everyday ideas about the scientific phenomenon on hand. In this paper, we argue that teachers need to develop knowledge around the varied ways their students make sense of the world around them so that when planning for instruction, teachers make their students' ideas central to the lesson design. As such, this study seeks to investigate how a single elementary teacher—Ms. Bernina—builds her knowledge about her students' everyday thinking and ideas around a single big idea in science (i.e. Why do we see stars only at night?) during a two part teacher professional development (PD) experience and considers this knowledge of her students' thinking as she revises a unit about this big idea.

Using Digital Simulated Classrooms to Examine Elementary Teachers' Ability to Engage Students in Scientific Argumentation

Jamie N. Mikeska, Educational Testing Service (ETS)
Pamela S. Lottero-Perdue, Towson University
Debra Brockway, Educational Testing Service
Andrew Finnegan, Educational Testing Service
Jonathan Steinberg, Educational Testing Service
Heather Howell, Educational Testing Service

ABSTRACT
In this study, we examined elementary science teacher competence in facilitating argumentation-focused discussions using a performance task and simulated classroom environment comprised of five upper elementary student avatars. This competency is essential for science teachers to be able to address the ambitious science teaching called for by the Next Generation Science Standards. It is particularly important as "engaging in argument from evidence" is one of the eight scientific practices necessary for deepening students' understanding of natural phenomenon and how scientific knowledge is constructed. This study's main research question is: How do participants' understanding of the task purpose, their performance scores, and their perceptions of task authenticity and usefulness compare across pre-service and in-service elementary teachers? Findings suggest that both groups perceived the performance task to be authentic and useful in teacher education. In-service teachers demonstrated that they were more likely to understand the intertwined content and practice goals of the performance task and were better able to engage students in scientific argumentation.

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

STEM integration across disciplines

2:40 PM-4:10 PM, Salon D

Presider: David McKinney, University of Nevada, Las Vegas

Comparison of Academic and Attendance Outcomes between an Integrated STEM High School and Comparison Schools

Carla C. Johnson, North Carolina State University
Toni A. Sondergeld, Drexel University

ABSTRACT
An integrated STEM approach to STEM schools has become more prominent as a way of addressing prior criticisms about STEM schools. This quasi-experimental study investigated the impact of one integrated STEM (I-STEM) high school on student academic performance, college readiness, and attendance in comparison to students from the same district. Findings revealed a significant difference on all outcomes with I-STEM students performing better than comparison students. Additionally, results demonstrated a reduction in traditional educational racial/ethnic and gender gaps for the I-STEM students.

Science and Literacy Integration by Secondary Science and English Language Arts Teachers

Laura E. Robertson, East Tennessee State University
ChihChe Tai, East Tennessee State University
Renee Rice Moran, East Tennessee State University

Karin Keith, East Tennessee State University

ABSTRACT
This study examined science and literacy integration reported by secondary science and English Language Arts teachers participating in a two-year professional development program. The Next Generation Science Standards and the Common Core Standards address the importance of integrating literacy skills across the content areas (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; NGSS Lead States, 2013); however, students and teachers may struggle during application (Ortmann, 2015; Plummer & Kuhlman, 2008; Zmach, et al, 2007). Data was gathered during focus groups of teachers (n=99) at two points during the professional development. Grounded in the theoretical framework of teacher belief, teacher responses were analyzed and data revealed patterns in frequency, strategies, collaboration, and barriers to integration by subject area. Two distinct approaches to integration were observed in the responses of teachers and are referred to by the authors as classroom level and team level integration. In conclusion, the authors offer a framework for integration which explains teachers' approaches to integration at the classroom and team levels and suggests methods for advancing science and literacy integration.

Semantic Patterns of an Integrated STEM Curriculum and its Enactment
Chelsey A. Dankenbring, Purdue University
Selcen Guzey, Purdue University
Lynn A. Bryan, Purdue University

ABSTRACT
Recent science education reform initiatives have called for the integration of STEM disciplines to provide a meaningful and authentic learning environment that facilitates science learning. This lead to the development of integrated STEM education which bridges the individual disciplines, often through the use of engineering design, as a means to teach and apply scientific concepts. However, participating in integrated STEM curricular activities can be cognitively challenging for students, thus it is important that teachers scaffold student learning, and one way this can be done is through classroom dialogue. This study examines a middle school integrated STEM curriculum and its enactment through the lens of Legitimation Code Theory (LCT) in order to map the semantic patterns present in the unit and to create a semantic profile of a teacher’s implementation of it. The results of this study indicate that LCT can be a useful tool for developing and examining integrated STEM curricular materials.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Frameworks of TA learning and development as educators
2:40 PM-4:10 PM, Salon C
Presider: Kübra Özmen, Baskent University

Cognitive demand of curricular activities and content-situated professional development influence teaching assistants' teaching practices
Jenna Hicks, University of Minnesota
Jessica Dewey, University of Minnesota
Michael Abebe, University of Minnesota
Anita Schuchardt, University of Minnesota

ABSTRACT
Little is known about how the cognitive demand of the curriculum intersects with instructor knowledge of teaching to impact instructors' practices. One difficulty with many professional development (PD) impact studies is that instructors in the comparison group often design their own lessons thus confounding practices and curriculum. This study leverages the unique setting of undergraduate laboratory courses where the activity is provided to all instructors [teaching assistants (TAs)], making it possible to parse the effects of curriculum and PD on instructor practices. PD situated in the context of specific activities designed to improve student-centered practices was provided to half the TAs. Cognitive demand of the activity (measured by the Task Analysis Guide in Science) is positively correlated with use of student-centered teaching practices (measured using the Reformed Teaching Observation Protocol). The intervention curriculum interacts with PD, resulting in the highest implementation of practices related to pedagogical content knowledge (PCK). Intervention TAs have higher implementation of practices related to PCK than do comparison TAs when teaching traditional activities. This suggests that PD situated within the context of specific lessons is effective in preparing TAs to implement similar teaching practices in novel activity contexts, with higher cognitive demand activities eliciting better practice.

Eliciting students' ideas: An exploratory study of biology teaching assistant learning
Anna S. Grinath, Idaho State University
Sherry A. Southerland, Florida State University

ABSTRACT
Although rigorous explanatory talk is a shared goal for science education, there is little support for teaching assistants (TAs) of undergraduate science laboratory courses to develop this practice. We explored TAs' yearlong trajectories of ambitious science teaching practice and their relation to TA beliefs and TA professional noticing. We selected three cases that varied in how TAs implemented this eliciting practice at the start of the year. In two cases, TA learning was evident by the overall increase in rigor of the discussions. In one case, the rigor declined. This variation is informative when we consider it with other factors that influence TA learning from a situative perspective. All TAs became more student centered in their surveyed beliefs about teaching, however the two cases that appeared more successful in taking up the ambitious practice also attended to more student-centered aspects of the learning environment in written reflections. Taken together, these case studies suggest that focusing an undergraduate biology lab curriculum and TA PD on eliciting student ideas may support more student-centered beliefs, however coaching TAs to develop professional vision around noticing student thinking may be an important way to support TA learning around eliciting student ideas.

Laboratory Teaching Assistants' Learning to Develop Ambitious Teaching Practices
Ryan Coker, Florida State University
Miray Tekkumru Kisa, Florida State University

ABSTRACT
This study focuses on the learning of novice teaching assistants (TAs) of a post-secondary general biology laboratory course. Seven TAs enrolled in a semester-long ambitious teaching professional development (ATPD) designed to promote understanding and use of ambitious teaching practices, specifically, their learning to elicit, assess, and use students' thinking. We explore TAs' orientations to student ideas and their role in teaching, and the pedagogical tensions that arise when they attempt to use ambitious teaching practices, particularly "eliciting, assessing, and using student thinking." TAs oriented to student thinking in many ways, including valuing students' ideas as the raw material of

learning in teaching. As they were working towards more complex forms of teaching science, TAs expressed pedagogical tensions such as covering the required content within an allocating time while at the same time opening a space for students' ideas and sensemaking. The preliminary findings have begun to provide consistent patterns with previous research on novice instructors' uptake of ambitious teaching, and also to expand it by uncovering the factors that may support or hinder in TAs' developing ambitious teaching practices. The study also provides implications for the design of professional learning opportunities for TAs in post-secondary biology education context.

Training for Culturally Responsive Science Teaching in Undergraduate Science Impacts Teaching Assistants' Practice

Hillary A. Barron, University of Minnesota - Twin Cities
Julie C. Brown, University Of Florida
Lorelei E. Patrick, Fort Hays State University
Sehoya Cotner, University of Minnesota

ABSTRACT
Utilizing pedagogies of empowerment such as culturally responsive science teaching (CRST) in undergraduate classrooms can mitigate the gatekeeping phenomenon often seen in science. Teaching assistants (TAs) engage in more one-on-one time with students than most faculty in undergraduate biology education, yet minimal pedagogical training is offered to them. Therefore, training for improved pedagogical knowledge is important for TAs, but training for culturally responsive science teaching is critical as TAs have broad and lasting impacts on students. Using constructivist grounded theory methods, this study explores the ways training for culturally responsive science teaching impacted undergraduate biology teaching assistants. This study applied grounded theory methodology to develop a theoretical understanding of the TA's experiences. Two major themes emerged from the data: Targeted Supports in CRST and TA Relationships with Students. These themes describe the ways in which training for culturally responsive science teaching impacted TA practice.

Strand 6: Science Learning in Informal Contexts

Admin Symposium-Igniting Informal Science

2:40 PM-4:10 PM, Salon E & F

Igniting Informal Science

Nancy L. Staus, Oregon State University
Anton Puvirajah, University of Western Ontario
Neta Shaby, Oregon State University
Dana Vedder-Weiss, Ben-Gurion University Of the Negev, Israel
Todd Campbell, University of Connecticut
Scott A. Pattison, TERC
Geeta Verma, University of Colorado Denver
Michael Dias, Kennesaw State University
John Pecore, Temple University
Smirla Ramos-Montañez, Oregon Museum of Science and Industry

ABSTRACT
The Igniting Informal Science session will consist of 8 ignite-style talks from researchers in the field of informal science. The session is designed to disrupt the usual didactic format of scientific talks and

instead convey information in an engaging and memorable way—by telling a story! Presentations will be 5 minutes long with 20 supporting slides that advance automatically every 15 seconds. This format emphasizes the Big Ideas and important findings of presenters' research. The final slide of each presentation will include a url or QR code containing information about how to acquire the full paper if people want to learn more. Such talks are becoming more common at professional meetings including the Ecological Society of America and are found to be quite engaging for viewers. In this session, the first talk will be about the ignite format itself and why we are trying it at NARST. The remaining 7 talks will cover a variety of informal science topics including development of STEM interest pathways in youth and science learning on the Appalachian Trail.

Strand 7: Pre-service Science Teacher Education
Building Knowledge through Asset-based Pedagogy
2:40 PM-4:10 PM, Salon A
Presider: Julianne A. Wenner, Boise State University

A Critical Examination of the Deficit Perspective in Science Education Preservice Teacher Knowledge Studies
Ron Gray, Northern Arizona University
David Stroupe, Michigan State University
Scott McDonald, Pennsylvania State University

ABSTRACT
The question of what preservice science teachers (PSTs) should know, and the purpose of such knowledge, are long-standing in science teacher preparation. The recent focus on teacher knowledge in various forms as the primary targets of acquisition for PSTs is, in part, because of calls for a professional knowledge base. Yet our experience at a recent conference left us wondering about foundational assumptions of these knowledge-focused questions. Specifically, we wondered why researchers positioned preservice teachers in terms of knowledge they “gained” or “lacked”. This deficit perspective runs counter to asset perspectives, in which researchers attempt to understand how PSTs make sense of and participate in the world of teaching and learning and where their knowledge was used as a resource to participate in and contribute to various practices. Here we present a literature review conducted to understand how cognitive and sociocultural learning perspectives treat PSTs in terms of a deficit or asset framing. We found a strong connection between cognitive studies and deficit perspectives and between sociocultural studies and asset perspectives. We hope this study can help open up the scholarly conversation about the kinds of knowledge we value for preservice teachers and how best to investigate their learning.

Pre-Service Science Teachers' Engagement with Asset-Based Pedagogies in a University Science Methods Course
Rachael M. Gordon, University of Michigan

ABSTRACT
This paper documents a qualitative study that explored one particular opportunity for pre-service secondary science teachers, henceforth interns, to develop asset-based pedagogies (e.g. culturally responsive, relevant, and sustaining; see Gay, 2000, Ladson- Billings, 1995, and Paris, 2012 respectively) throughout a one-semester university methods course. Seven interns' coursework was analyzed to explore the following research questions: How do interns write about asset-based pedagogies, and what

connections might they make between their ideas and methods course instruction? To what extent do interns make explicit connections between science content and asset-based pedagogies as discussed and developed in the methods course? Findings include: interns were able to articulate notions of asset-based pedagogies, though disconnects arose between science content and asset-based instructional strategies. The study has implications for science teacher education design and university-mentor teacher partnerships.

Access Points that Facilitate Preservice Teachers' Sense-making about Systemic Issues within a Field Experience.

Victor Kásper, Florida State University
Lama Jaber, Florida State University
Shannon G. Davidson, Florida State University

ABSTRACT

This paper documents a qualitative study that explored one particular opportunity for pre-service secondary science teachers, henceforth interns, to develop asset-based pedagogies (e.g. culturally responsive, relevant, and sustaining; see Gay, 2000, Ladson- Billings, 1995, and Paris, 2012 respectively) throughout a one-semester university methods course. Seven interns' coursework was analyzed to explore the following research questions: How do interns write about asset-based pedagogies, and what connections might they make between their ideas and methods course instruction? To what extent do interns make explicit connections between science content and asset-based pedagogies as discussed and developed in the methods course? Findings include: interns were able to articulate notions of asset-based pedagogies, though disconnects arose between science content and asset-based instructional strategies. The study has implications for science teacher education design and university-mentor teacher partnerships.

Strand 7: Pre-service Science Teacher Education

Preservice teachers' self-efficacy in engineering

2:40 PM-4:10 PM, Salon B

Presider: Jing Yang, Indiana University

Sources of Engineering Teaching Self-Efficacy in a STEAM Methods Course for Elementary Pre-service Teachers

Donna L. Webb, George Fox University
Keelan P. LoFaro, Portland State University

ABSTRACT

This study investigated the effect of a STEAM (science, technology, engineering, arts, and mathematics) methods course on elementary pre-service teachers' (PTs') perceptions of self-efficacy to teach engineering. The course positioned engineering as the primary content area from which to integrate other subjects. To enhance PT's perception of engineering self-efficacy, the course provided instruction that leveraged the following sources of self-efficacy: cognitive content mastery, cognitive pedagogical mastery, vicarious experience, verbal persuasion, and emotional state. As such, the study also examined to what extent the various sources of self-efficacy contributed to changes in engineering self-efficacy. Data sources administered to fourteen participants included a self-efficacy survey and focus group interview. After completing the course, elementary PTs' self-efficacy to teach engineering increased significantly. Qualitative data analysis revealed cognitive pedagogical mastery, vicarious experience

(specifically simulated modelling), and emotional state were the most influential sources linked to positive changes in self-efficacy, with cognitive content mastery, and other forms of vicarious experience contributing, but to a lesser degree. Results from our study suggests teacher preparation programs can better support elementary PTs to teach engineering by offering additional methods courses focused on engineering, rather than providing short-term exposure to engineering pedagogy in overloaded science methods courses.

Preservice Teachers' Self-Efficacy Beliefs about Scientific Practices: Validation of the Science and Engineering Self-efficacy Instrument

Fatma Kaya, Kent State University
Lisa A. Borgerding, Kent State University
Shannon Navy, Kent State University

ABSTRACT

This study validates an instrument, the Teacher Efficacy about Teaching Science and Engineering Practices (TE-TSEP), to be used to measure preservice teachers' self-efficacy beliefs about the science and engineering practices. Using the instrument, it also compares the self-efficacy of the science and engineering practices of preservice teachers enrolled in a science methods course to those not enrolled in a science methods course. The participants, 101 elementary preservice teachers, were from a large university in the Midwest United States. Fifty-six of the participants were enrolled in a science methods course and responded to the survey. The Rasch model (Boone et al., 2014) was used to calculate the survey reliability. In addition to this, a one-way ANOVA determined significant differences between the preservice elementary teachers who took the science methods course and did not receive instruction in a science methods course. Therefore, in addition to developing and validating the TE-TSEP, this study indicated significant differences between preservice teachers enrolled in a science methods course and those not enrolled in a science methods course in their self-efficacy of four of the eight science and engineering practices.

Effects of Informal versus School-Based Field Experience on Elementary Preservice Teachers' Self-Efficacy for Teaching Science

Nicole Hesson, York College of Pennsylvania
Jason Forsyth, James Madison University

ABSTRACT

The purpose of this longitudinal project is to determine the effect of an engineering capstone greenhouse project on the science teaching self-efficacy of elementary preservice teachers. Prior to the fall semester of 2017, the elementary preservice teachers who were enrolled in a science methods course engaged in a variety of field experiences across different settings, mostly informal. Beginning in the fall semester of 2017, students enrolled in this science methods course have completed their field experience in formalized classroom settings. Most students have been placed at the site of the greenhouse partnership school, a K-8 school in the local urban school district. At the outset, the original study aimed to compare the self-efficacy for science teaching of the elementary education preservice teachers pre- and post-greenhouse implementation. However, the construction of the greenhouse was delayed and thus created a third cohort of students in addition to pre- and post-greenhouse. This third group of students has been placed in a K-8 school setting, but has not had access to the greenhouse. This paper compares the first two cohorts of preservice teachers, those who completed informal field experiences and those who completed school-based field experiences without the utilization of the greenhouse.

Strand 8: In-service Science Teacher Education

Assessment to Support NGSS Implementation

2:40 PM-4:10 PM, Pearl

Presider: Kerri Wingert, University of Colorado at Boulder

A 'Levels of Engineering Design' Rubric for Science Teachers Incorporating NGSS

Sarah B. Boesdorfer, Illinois State University

ABSTRACT

With the inclusion of engineering design, the Next Generation Science Standards (NGSS) has asked science teachers to include concepts in their science teaching which, for a large majority, has not been a part of their educational preparation. As science teachers worked and continue to work to incorporate science inquiry into their teaching, levels of inquiry frameworks (e.g. Bell et al. 2005) help science teachers learn about and incorporate inquiry in their classrooms. They are tools to help teachers, teacher educators, and researchers increase inquiry in the science classroom. A similar tool could have similar benefits for helping science teachers incorporate engineering design in their science classrooms to meet NGSS. This paper describes the development and initial validation of such a tool, the Levels of Engineering Rubrics. Initial secondary science teachers' reactions to the rubric were positive and are discussed in the paper along with possible uses of for the rubric and continued research.

Characterizing Multi-dimensional, Teacher-designed, Science Assessments: Dimensions, Integration, and Cognitive Demand

Laura Zeller, University of Illinois at Chicago
Donald J. Wink, University of Illinois at Chicago

ABSTRACT

A Framework for K-12 Science Education (NRC, 2012) and the NGSS (NGSS Lead States, 2013) explicate what science content and practices students should be learning. Research is needed on how to analyze alignment of assessments to NGSS and integration (Fulmer, Tanas, & Weiss, 2018). The Task Analysis Guide in Science (TAGS) provides a way of categorizing tasks based on their integration of science content and practices and their cognitive demand level (Tekkumru-Kisa, Stein, & Schunn, 2015). We extend the TAGS by using a finer-grainsized comparand and NGSS and Framework specific referents to describe three teacher-designed assessments from a teacher-pair participating in an NGSS assessment literacy focused professional development (PD). The TAGS categorizes all the assessments as guided integration, but our analysis also reveals specific trends and differences across the disparate tasks. There are patterns of multiple practices supporting each other and of non-integrated parts of assessments being used to scaffold to integrated parts. This fine-grained analysis differentiates between assessments beyond what TAGS alone can do, providing a basis for comparison across PD participants and over time. Comparison across a broader sample of teacher-designed assessments in future work will serve as a basis for examining how PD influences teacher thinking.

Impact of Scoring the Illinois Science Assessment on K-12 Science Teachers' Practices

Senetta F Bancroft, Southern Illinois University Carbondale
Harvey Henson, Southern Illinois University
Daniel L. Brown, Illinois State Board of Education
Angela D. Box, Southern Illinois University-Carbondale

Yanyan Sheng, Southern Illinois University-Carbondale
Jennifer Rhodes, Southern Illinois University-Carbondale

ABSTRACT
The three-dimensional (3D) framework of the Next Generation Science Standards (NGSS) stresses teaching K-12 science with increasing coherency and complexity within and across disciplines and grade levels. Naturally, the 3D framework also challenges science educators and states to rethink the criteria by which they assess students. In 2016, the state of Illinois administered its first NGSS aligned state science assessment, the Illinois Science Assessment (ISA). The ISA included, in part, non-machine scorable constructed response items, which focus primarily on students explaining phenomena. The scoring process includes scorer training in interpreting students' responses relative to pre-determined rubrics and establishing and maintaining good inter-rater reliability. The scoring process, therefore, provided scorers with some insight into the state's expectations of what students should know and be able to do in science and the role rubrics play in evaluating those expectations. We discuss the: i) collaborative process between Illinois's State Board of Education and Southern Illinois University's STEM Education Research Center to score the ISA, ii) development of a tool that yielded valid and reliable data to evaluate the scoring process's impact on educators' instructional and assessment practices, and iii) impact of scoring on educators' instructional and assessment practices.

Interpreting Teacher Understanding of 5D Science: A Vision Survey
Kerri Wingert, University of Colorado at Boulder
Melissa R. Campanella, CU Boulder
William R. Penuel, University of Colorado
Kris Kilibarda, Iowa Department of Education

ABSTRACT
The NAP Guide to Implementing the Next Generation Science Standards (NRC, 2015) describes what science education leaders need to do to both establish and support a new vision for science learning that links science knowledge with practice into three dimensions, articulates how understanding develops over time, and asserts that instruction should connect to interest and identity and promote equity (NRC, 2012; NGSS Lead States, 2013). It is a bold vision that cannot be achieved through simply disseminating guiding documents. Instead, to support its implementation requires coordinated planning that builds on what we know about teacher learning and the link between teacher vision and practice (NRC, 2015; Corno, 2004; Hammerness et al., 2005; Feiman-Nemser, 2001). In short, leaders need ways of understanding where teachers' visions are with respect to this target vision so that they can plan effective support. In this paper, we present two iterations of a vision survey instrument designed to fulfill that need, exploring how science education leaders leveraged the original tool (Weidler-Lewis, Penuel, & Van Horne, 2017) and sharing our process to revise the instrument and test the updated version. Full copies of both surveys are presented and national pilot results for the revised instrument are described.

Strand 10: Curriculum, Evaluation, and Assessment
Automated Assessment of Argumentation in School Science: Developments and Challenges
2:40 PM-4:10 PM, Columbia

Selected Response Item Formats: Addressing the Practice of Arguing From Evidence in Science
Linda Morell, University Of California, Berkeley

Sara J. Dozier, Stanford University
Weeraphat Suksiri, University of California, Berkeley
Jonathan Francis Osborne, Stanford Graduate School Of Education
Mark R Wilson, University of California, Berkeley

Using automated analysis to assess middle school students' competence with scientific argumentation
Christopher Wilson, BSCS
Molly Stuhlsatz, BSCS
Brian M. Donovan, BSCS
Zoe E. Buck Bracey, BSCS
April L. Gardner, Biological Science Curriculum Study

Automated real-time argument-text and model-interaction feedback to support secondary school students' revision of scientific arguments
Hee-Sun Lee, The Concord Consortium
Gey-Hong Gweon, Physics Front
Amy R. Pallant, The Concord Consortium

Exploring bias in automated scoring of student argumentation
Zoe E. Buck Bracey, BSCS
Molly Stuhlsatz, BSCS
Tina Cheuk, Stanford University
Marisol Mercado,
Christopher Wilson, BSCS
Jonathan Francis Osborne, Stanford Graduate School Of Education
Kevin C. Haudek, Michigan State University
Brian M. Donovan, BSCS
April L. Gardner, Biological Science Curriculum Study

ABSTRACT
This symposium will be an opportunity to hear about 4 research-based approaches to the computer-based assessment of scientific argumentation and the nature and quality of the feedback these approaches provide. Machine learning and AI are set to transform complex tasks in the coming decades and this symposium will present developments in the field of student argumentation in science. Three of the four approaches draw on machine learning and natural language processing to automate the process of scoring. The fourth paper examines issues raised for English Language Learners by such an approach. Automated assessment has can provide a) immediate student feedback, and b) immediate data for the teacher to inform the pedagogic choices that they then make. Thus, they have the potential to enhance the quality of formative assessment and improve personalized feedback. The four papers in this coordinated session use data drawn from Grade 6 to 12 and a diversity of scientific contexts. The symposium provides an opportunity to learn about both the success and challenges of these different approaches and to contrast the strengths and weaknesses of each.

Strand 10: Curriculum, Evaluation, and Assessment

Teachers' Understanding and Use of Science Curriculum and Assessment

2:40 PM-4:10 PM, Salon I

Presider: Lisa M. McDonald, Columbia University

"We Get to See What Works": Teacher Commitment to Curriculum within a Research Practice Partnership

Jayma Koval, Georgia Institute Of Technology
Jessica Gale, Georgia Institute Of Technology - CEISMC
Meltem Alemdar, Georgia Institute Of Technology
Sabrina Grossman, Georgia Institute Of Technology - CEISMC
Marion Usselman, Georgia Institute Of Technology

ABSTRACT

In 2002, NSF launched the Math and Science Partnership (MSP) program to support innovative partnerships to improve K-12 student achievement in math and science. Supported by an MSP, the project established a Research Practice Partnership (RPP) that iteratively developed week-long math and science curriculum modules organized around three unifying practices: experimental design, data-driven decision making, and data visualization. To prepare to implement this new curriculum in 6-8thgrade classrooms, teachers participated in extensive professional development workshops and received ongoing support from the project team. This study utilizes interview and document data collected during and following the project to explore factors influencing teacher commitment to implementing and sustaining innovative curricula at the classroom level. Findings indicate that, over the course of the project and beyond, three main factors explained teachers' high level of commitment to implementing and sustaining the curriculum modules: observations of student learning and engagement, the degree to which the modules were consistent with other school and district initiatives, and professional development experiences. This study describes how each of these factors influenced teacher commitment to curriculum along with implications for research practice partnerships.

How Teachers Understand the Curriculum and Frameworks They Use

Kristin N. VanWyngaarden, University Of Nebraska Omaha
Michelle Friend, University of Nebraska at Omaha

ABSTRACT

This study investigates and compares teachers' understanding of two curricular frameworks: Next Generation Science Storylines and the 5E Model. Elementary teachers participated in a three-week summer workshop designed to introduce elementary teachers to biomechanics, the study of the body in motion and help them develop inquiry-based biomechanics lessons using the NGSS Storyline framework in order to enhance their implementation of interdisciplinary, culturally responsive, and technology-enhanced STEM education. During a follow-up session to the workshop, eleven teachers read an article about implementing biomechanics into school science (Trauth-Nare, Pavilonis, Paganucci, Ciabattoni, & Buckley, 2016); this article used the 5E framework, which some of the teachers were already familiar with. Teachers then discussed the article and compared and contrasted the 5E model with the Storyline framework. The transcript was analyzed to understand how the teachers understand the frameworks individually and in comparison. Teachers identified surface similarities and differences between the models, such as the iterative nature of storylines. They felt that storylines were better at supporting inquiry due to being more student-driven than 5E lessons. Implications for the nature of curricular

framework in supporting inquiry and issues of supporting teachers in moving to a new style of lesson planning are discussed.

Teacher Decision-Making in High School Biology Curriculum Co-Design: A Critical Incidents Analysis
Elizabeth Chatham, New Visions for Public Schools
Kiran D. Purohit, New Visions for Public Schools

ABSTRACT
The adoption or adaptation of Next Generation Science Standards in many US states requires teachers to develop new understandings of curriculum, classroom instruction, and assessment. For high school teachers, the shift is uniquely dramatic, as many have not had opportunities to learn science as a sense-making, collaborative endeavor, as it is envisioned to be in the K-12 Framework. Curriculum co-design has emerged as a powerful professional learning process for teachers, but there are concerns about the cost and sustainability of such co-design efforts. This study investigates the ways in which curriculum co-design supports high school teachers to shift their practice, asking What is the role of curriculum co-design as a professional learning experience in ensuring widespread access to ambitious materials? Through an analysis of teacher decision-making in several critical incidents from the co-design of two high school biology units, the researchers draw out four major interpretive lines that support a model for incorporating aspects of curriculum co-design into professional learning experiences at scale. These findings are presented to support those who are designing learning spaces to support profound shifts in teacher practice, while attending to the complexity of teacher decision-making about instruction.

Using Hybrid Online/Face-to-Face Courses to Support Teachers' Development and Use of 3D Performance Assessments
Jill Wertheim, Stanford Center for Assessment, Learning, and Equity

ABSTRACT
High-quality classroom assessments are a powerful tool for supporting and monitoring implementation of the NGSS. Yet, there are few high-quality assessments available for the NGSS, and few professional learning opportunities on developing or using multidimensional assessments to inform instructional decisions. This study explores the impacts of a series of free, hybrid online-face-to-face courses on performance assessment for NGSS on teachers' development and use of assessments to support students' three-dimensional reasoning. Data were collected from observations, interviews, and artifact analysis as two cohorts of teachers (5 from grades K-6 and 5 from grades 7-12) used an online course to develop and use an instructionally-embedded performance assessment. The tasks the participants developed demonstrated some success in using the principled-design approach, but the impacts of the development process extended far beyond the task to changing participants' ideas about the role of assessment in classrooms, what it means to engage in multidimensional reasoning, ways that a focus on authentic problems can drive engagement in science, and how collaboration around assessment can support coherence in instruction throughout a school. Outcomes of this study have implications for the strengths and weaknesses of online professional learning and capacity-building for NGSS implementation.

Strand 11: Cultural, Social, and Gender Issues
Creating Space for the Inclusion of Social Justice within Engineering Learning Environments
2:40 PM-4:10 PM, Salon G
Discussant: Bryan Brown, Stanford University

An Identity Resources Approach for Supporting Teachers-of-Engineering for Minoritized Young People
Christopher G. Wright, Drexel University
Bryan A. Brown, Stanford University
Rasheda Likely,
Mikhail Miller, Drexel University

Design Problems in Context: A Longitudinal Examination of Students' Design Considerations in a Course about Engineering Culture, Diversity, and Equity
Greses Pérez, Stanford University
Shannon Gilmartin, Stanford University
Carol Muller, Stanford University
Patrick Danner, Stanford University
Sherri Sheppard, Stanford University

Becoming Part of an Engineering Community of Practice: How Students Across Lines of Difference Find Their Place in a Makerspace
Eric Reynolds, Stanford University

My Life's Work: Re-engineering Education for Black Boys
James Holly, Jr., Wayne State University

Design Justice in Humanitarian Engineering Education
Brandon Reynante, Stanford University

ABSTRACT
Engineering education has typically focused on supporting individuals' development of cognitive understandings and skills in engineering content and/or pedagogy. While these are essential pathways to becoming members of the engineering community, recent research has called for a moire systematic inclusion of social science and humanistic knowledge. In this set of proposed papers, we explore various approaches for examining the inclusion of equity and social justice issues within engineering education. Specifically, these papers consider ways of foregrounding these issues within undergraduate engineering programming and in the design of spaces of precollege teacher education. With this collection, we look to advance conversations about the potential role of equity and social justice within spaces of engineering learning.

Strand 11: Cultural, Social, and Gender Issues
Exploring the Experiences and STEM Identity Development of Black Students and Teachers
2:40 PM-4:10 PM, Salon H
Presider: Reanna S. Roby, Michigan State University

A Narrative Inquiry into the Making of an Urban Science Teacher: Felicia's Story
Lisa Marco-Bujosa, Villanova University

ABSTRACT
The purpose of this case study was to examine a secondary science teacher's development of an identity for urban teaching. Utilizing a narrative inquiry approach, data collection spanned three years of a graduate teacher education program and the first two years of teaching. Data was collected in the form of periodic interviews, lesson plans, and written reflections. Analysis was guided by a sociocultural framework of teacher identity, which considers learning to teach to be an active social, relational, and contextually-situated process. Findings are presented under the four sociocultural dimensions of identity: nature – contending with her outsider status; institutional – encountering school barriers to science teaching; discourse – teaching to integrate science and social justice; and affinity – social supports and relationships. Implications for research and practice are discussed.

Examining Factors Influencing African American Students' Scientific Identity in STEM
Lezly Taylor, Virginia Polytechnic Institute and State University
Brenda R. Brand, Virginia Tech University
Takumi Sato, Virginia Polytechnic Institute & State University
Anza Mitchell, Virginia Tech University

ABSTRACT
The Science Technology Engineering and Mathematics (STEM) agenda encompassed simplified educational initiatives concerning cultivating STEM literate students in response to the increasing demand of STEM careers, the evolving technocratic society, and economic global competitiveness across technology and science sectors. The underrepresentation of marginalized groups across STEM fields has gained attention. While there has been some progress, these groups lag significantly behind in the percentages of STEM degrees awarded. Research reports factors such as self-efficacy beliefs, predominant profiles of successful scientists, and misconceptions about engineering practices influence the STEM aspirations of underrepresented students. Hutchison-Green (2008) asserted that educators should seek to build students' self-efficacy very early by providing them with experiences that lead to mastery of certain skills. Estrada-Hollenbeck, Woodcock, Hernandez, and Schultz (2011) indicated that while self-efficacy is a predictor of STEM persistence, identification as scientists and sense of belonging to a scientific community are higher predictors. Changes in self-efficacy and scientific identity of African American students participating in a NSF funded pre-engineering afterschool program were examined in this longitudinal mixed methods research study. Quantitative and qualitative findings related to scientific identity reveal evidence of resocialization in the scientific identity of students who persisted.

Exploring Discursive Performance of Race in Advanced Placement Biology Classrooms
Deborah J. Tippins, University Of Georgia
Sophia (Sun Kyung) Jeong, University of Georgia

ABSTRACT
This study is part of a larger research study which aimed to investigate the conditions under which capacities of gender and race became actualized in the science classrooms (Author, 2018). In this presentation, we aimed to show how students discursively performed race. Here, we problematize the black-boxing of one's identity categories (i.e., Race, Gender with the capital R and G) as attributes of individuals that are immovable, monolithic and deterministic. Rather, we argue that it is defined through the observations of how individuals interact with each other and would not be defined outside of how individuals in the network choose to do so. Our particular understanding of race is informed by Bruno Latour's work on actor-network theory (ANT). Thus, we examined race through its ontological work. To this end, we still know very little about how these norms and

conventions are negotiated by students and teachers at the level of immediate classroom interactions. The overarching aim of this study was to explore the ontological complexity of race that becomes available to students in the science classrooms. Empirically speaking, the purpose of this study was to describe the conditions under which the capacity of race became actualized in the science classrooms. Results showed complexities of race as effects of heterogenous assemblages and conditions under which the actualization of race took off in a direction away from the science curriculum.

Identity Formation in Science During Adolescence: How do Future Possible Selves Take Shape For Diverse Students of Color?

Ross Anderson, Inflexion
Ed Madison, University of Oregon
Niki Derosia, University of Oregon

ABSTRACT
This study explores how students of color in late adolescence form and sustain a science identity and the potential positive role of near-peer mentoring experiences. There continues to be a well-documented underrepresentation of students from racial and ethnic minority backgrounds in science pathways. We followed an identity-based motivation framework and near peer mentoring format to pursue this investigation with twelve students in high school and undergraduate science programs. We found the near peer relationship did not focus on science content knowledge, primarily, but rather on candid descriptions of experiences as a student of color in science. Our preliminary findings demonstrate the importance of opportunities to exchange social-cultural aspects of engagement in science and the contextualized construction of science identities.

Strand 12: Educational Technology

Technology Tools to Support Scientific Thinking

2:40 PM-4:10 PM, Portland

Presider: Kit Martin, Northwestern University

Blending Drama and Computer Supported Collaborative Learning for Socioscientific Argumentation

Aysegul Oguz Namdar, Recep Tayyip Erdogan University
Bahadir Namdar, Recep Tayyip Erdogan University

ABSTRACT
The purpose of this theoretical paper is to provide a blended learning and teaching sequence for socioscientific argumentation. The paper advocates for blending creative drama and socioscientific argumentation through computer supported collaborative learning. We see this blended sequence as particularly important because scientific literacy includes both reading and writing. Additionally, integrating multiple representations into the explaining and decision making processes is a venue for fostering scientific literacy. This proposal also illustrates our rationale and methodology for the proposed sequence. First, we identify the importance of socioscientific issues and argumentation in science education. Second, we note two challenges in socioscientific argumentation and propose experiential drama and computer-supported collaborative learning as two venues for overcoming these challenges. Third, we introduce a teaching and learning sequence blending these tools. Finally, we introduce a CSCL environment called "innovative Knowledge Organization System" and give an example lesson plan incorporating this sequence in the context of using socioscientific argumentation to teach genetically modified organisms.

Impacts of Sequential Experience with Agent-Based Modeling and System Dynamics Modeling on Students' Ability to Link Across Levels in Reasoning about Complex Phenomena

Jie Chao, The Concord Consortium
Carolyn Staudt, Concord Consortium
Daniel Wendel, Massachusetts Institute of Technology

ABSTRACT

Real-world systems dynamics problems involve multiple complex systems and the interactions between them. Preparing learners to reason about such systems requires developing their ability to navigate and understand systems at multiple levels. The goal of this study was to characterize the development of student understanding of the links between agent-level and system-level entities, properties, and events in complex systems, as a result of creating and analyzing models in an agent-based modeling environment followed by equivalent activities in a system dynamics modeling environment. In a week-long unit on modeling evolution, students were guided to create and analyze computational models for three experiments of bacterial growth. Students completed a Modeling Evolution questionnaire at the beginning of the activities and again at the end. The authors developed a coding scheme that first identifies each expression as describing agent-level or system-level entities, properties, and events; then examines the causal links between expressions and labels the links as cross-level links, same-level links, or other types of links. The authors are currently analyzing the data using the coding scheme described above. Findings will reveal the impacts of sequential experience with agent-based modeling and system dynamics modeling on students' ability to link across levels in reasoning about complex phenomena.

Much.Matter.in.Motion: 7th Grade Students Learn Chemistry through Constructing Computational Models of Complex Systems

Janan Saba, University of Haifa
Sharona T. Levy, University of Haifa
Elon Langbeheim, The Weizmann Institute Of Science
Hagit Hel-Or, University of Haifa

ABSTRACT

The paper presents a study into students' learning of the topic of gases in chemistry through constructing computational models of complex systems with the new Much.Matter.in.Motion platform (MMM; Levy, Saba, et al., 2018). The design of the MMM platform based on agent-based modelling approach.it intends to highlight the thinking which takes place when modeling complex systems. This epistemological structure defines entities and their properties, as well as their actions and interactions with each other and with macro-level boundaries and fields. 22 Seventh-grade students' learning of science concepts, systems components, and modeling practices by constructing models is compared with 28 students' learning with a normative curriculum. Results show that interaction between time and group shows superior learning of the experimental group. The specific components contributing to these differences is science concept of Kinetic Molecular Theory and systems reasoning at the micro-level. The research findings suggest that modeling with MMM supports learning of science, systems, and modeling. Conceptual learning is deeper and more integrated. Systems levels are better distinguished and related. Students' modeling expresses gradually increasing explorative-ness and most importantly, the gradual shift from relying on the external modeling platform to activating and developing their own internal mental models.

Strand 14: Environmental Education

Environmental Education - educator's perspective

2:40 PM-4:10 PM, Eugene

Presider: Iris Alkaher, Kibbutzim College Of Education

Framing Differences Reveal Argumentation Complexities in Education for Sustainability – The Case of Natural-Gas Distribution

Hagit Shasha Sharf, The Technion, Israel Institute of Technoloy
Tali Tal, Technion

ABSTRACT

In this case-study, we give special attention to the way environmental-sciences teachers argue about an environmental and economic controversy, concerning natural-gas as public non-renewable energy resource. Discussing the controversy took part during a socio-scientific issue-oriented professional development for 20 environmental-sciences teachers. We employed a perspective of framing and figured worlds to analyze a group discussion that was videotaped, focusing on an episode of disagreement between two teachers. Through qualitative discourse analysis we found different framing of the natural-gas debate by the teachers. In this presentation we show how one teacher figured the dilemma in frames of "Energy resource problem-solving", "Foreign-affairs and international trade", "Environmental technological development optimism " and "Big scale infrastructure project"; while, another teacher framed the same dilemma as "Distributional justice", "An opportunity to minimize consumption", "State control of resource exploitation" and "Green organizations' positions". We argue that these different series of frames reflect a larger cultural, social and ideological debate over sustainability policy, which can be identified also as "neo-classical economic" and "ecological-economic" conceptions, having important role in argumentation processes over the social aspects of energy resources. This study aims to address the relative absence of the economic domain in the education for sustainability literature.

How do Faculty at a Business School Conceptualize Environmental Issues and Incorporate these Issues in their Classrooms?

Hamza Malik, University Of Massachusetts Dartmouth
Stephen B. Witzig, University Of Massachusetts Dartmouth

ABSTRACT

Environmental issues are threatening the core existence of human beings around the globe and it is considered to be one of the biggest challenges for our survival. A role of education should be to meet these challenges like environmental issues head-on by teaching students about the importance of these issues. As such, human impacts on the environment have been highlighted in the Next Generation Science Standards. The purpose of this qualitative research study was to understand how faculty at a business school conceptualize environmental issues and incorporate these issues in their classroom. This was a two-fold research study where the first objective was to understand how faculty conceptualize environmental issues using narrative inquiry. Secondly, how they (faculty) present these environmental issues in their classrooms using document analysis. We used narrative inquiry to understand the point of view of the participants, in order to recognize real-life stories of these faculty members and how these stories have impacted their understanding of environmental issues. Following data analysis, we found that faculty members conceptualize environmental issues using their personal experiences like past education or volunteer experience and they incorporate these issues using both formal and informal

means of instruction.

Population Growth: Do Teachers Perceive It As A Problem And What Are Their Concerns About Including It In Their Teaching?

Iris Alkaher, Kibbutzim College Of Education
Nurit Carmi, Tel Hai Academic College

ABSTRACT
The enormous contribution of human population growth (PG) to the environmental crisis is indisputable. However, relatively little attention has been paid to PG in the media, or by governments, environmentalists and educators. While educators mostly agree to include controversial environmental topics in school curricula, calls for addressing PG remain rare. This study explores teachers' perspectives of PG as a problem and their attitudes towards including it in their teaching, focusing on E-teachers (with a background in environmental-oriented academic programs) and non-E teachers (with no such background). While perceiving PG as an environmental problem and supporting its inclusion in schools was significantly higher among the E-teachers, similar concerns were reported by all the teachers. This consensus indicates the limited impact of knowledgeability on teachers' intentions to address PG in class. Teachers' challenges focus on socio-cultural-political reasons. The findings demonstrate how the absence of PG from the public discourse and from school curricula influences teachers' preparedness and willingness to address it in their teaching. This study highlights the necessity to encourage teachers to address PG in their teaching by providing them with appropriate knowledge and skills that will enable them to successfully engage students in this controversial issue.

Pre-service secondary teachers' emotional sense-making of learning to teach climate change

Elizabeth Hufnagel, University of Maine
Anica Miller-Rushing, University of Maine

ABSTRACT
The purpose of this study was to examine the ways pre-service secondary science teachers (PSSTs) emotionally made sense of learning to teach climate change in a science methods course. Since emotions both indicate what one cares most about and why and informs teaching practices, we sought to contribute to a gap in the climate change education research. Research on the role of science teachers' engagement with climate change centers on conceptual knowledge, beliefs, and pedagogies, leaving space to understand more about PSSTs' personal, or emotional, engagement with learning to teach climate change. Drawing from scholarship on emotional sense-making, we highlighted the ways in which pre-service science teachers expressed tensions and excitements about learning to teach climate change in a graduate level science methods course for pre-service secondary teachers. In doing so, inter-related themes about the emotional tensions underlying their identities as science teachers and climate change educators became salient. In this presentation, we discuss these themes and explicate implications for the teaching and learning of science.

Concurrent Session 2
4:20 PM-5:50 PM

Strand 1: Science Learning, Understanding and Conceptual Change
Recent Trends in Genetics Education Research
4:20 PM-5:50 PM, Salmon
Presider: Kostas Kampourakis, University Of Geneva

Mechanistic reasoning about gene environment interactions
Michal Haskel-Ittah, Weizmann Institute of Science
Ravit Golan Duncan, Rutgers University
Anat Yarden, Weizmann Institute Of Science

High school students' causal attributions of features of the body and the mind: Genes, environment and individual will
Marcus Hammann, Münster University

Supporting the development of genomics literacy could significantly reduce cognitive forms of racial prejudice during adolescence
Monica Weindling, BSCS Science Learning
Brae Salazar, BSCS Science Learning
Brian M. Donovan, BSCS

Measuring students' teleological and essentialist conceptions in the context of genetics: A comparison of explicit and implicit measures
Florian J. Stern, University Of Geneva
Kostas Kampourakis, University Of Geneva
Marine Delaval, University of Geneva
Andreas Mueller, JUFE (University Of Geneva)

Defining epigenetic literacy for school biology – A Delphi study
Niklas M. Gericke, Department of Environmental and Life Sciences
Birgitta Mc Ewen , Department of Environmental and Life Sciences, Karlstad University
Karin Thörne, Department of Environmental and Life Sciences, Karlstad University

ABSTRACT
Genetics is a very active field of contemporary scientific research, constituting the basis for medical genetics, personalized medical genomics, forensics, biotechnology and, more generally, our understanding of health, disease, behavior, and identity. Achieving genetics literacy is therefore a crucial component of science literacy. However, public understanding of genetics seems to be relatively low. Therefore, for the purpose of educating scientifically literate citizens, it is important that genetics education accurately represents the current conclusions of genetics and genomics research. However, research has also revealed difficulties that secondary students have in understanding genetics. Particular difficulties have also been documented in secondary students' reasoning about socio-scientific issues related to genetic technologies. Finally, there are important conceptual issues that need to be clarified, both about how key genetics terms such as "gene" are defined and about what conclusions can be drawn for genetics education from the history and philosophy of the discipline. Therefore, further

research is required in order to achieve effective teaching and learning in genetics. The papers in the proposed related paper set present recent research in new underexplored areas of genetics education and reveal issues that should be addressed in genetics teaching and learning.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Improving Guidance for Classroom Argumentation in Science Inquiry

4:20 PM-5:50 PM, Mt Hood

Discussant: Marcia Linn, University of California-Berkeley

Changes in Classroom Argumentation Practices in Elementary Science during Teachers' Participation in a Year-Long Professional Development Program

Coralie F. Delhaye, Stanford University
Matthew Wilsey, Stanford University
Emily Reigh, Stanford
Hilda Borko, Stanford University
Jonathan Francis Osborne, Stanford Graduate School Of Education

Supporting Student-Directed Discussion in Elementary Science: A Case Study of One Teacher's Instructional Change

Emily Reigh, Stanford
Florencia Gomez Zaccarelli, Facultad de Educación, Pontificia Universidad Católica de Chile
Hilda Borko, Stanford University
Jonathan Francis Osborne, Stanford Graduate School Of Education

Learning to revise: Using Annotation to Model Integrated Revision of Explanations

Libby Gerard, UC Berkeley Graduate School of Education
Marcia C. Linn, University of California-Berkeley

Impact of Autoscored Student Data Reports on Teacher Customizations and Students' Science Learning

Jennifer King-Chen

Supporting Teachers to Customize Science Curriculum for Self-directed Learning Impacts Both Teacher and Student Learning

Allison Bradford, University Of California - Berkeley
Libby Gerard, UC Berkeley Graduate School of Education

ABSTRACT

This paper set explores avenues for improving argumentation in classroom science inquiry instruction. The paper set couples approaches for supporting teachers and students to make inquiry science learning successful in diverse, K-8 science classrooms. Three studies investigated professional development that supports teachers to develop research-based strategies for guiding argumentation, and to customize curriculum to motivate their students to take ownership for developing and revising arguments. Two papers leverage automated scoring of student written arguments to promote productive revision using evidence. In one, teachers are supported to use automated scoring of student explanations to improve inquiry by building on students' ideas. In the other, students are supported to annotate their own or a fictional peer's argument to develop a model of the process of argument revision. Studies leverage qualitative and quantitative methods including classroom video analysis, interviews, embedded

assessment, logged data and pretest/posttest measures to warrant findings. The findings identify clear techniques to strengthen teacher ability to succeed with inquiry science and to improve student success in writing about their inquiry findings. The discussant will introduce the five papers (5 min); each presenter will present (11 min/presenter; 55 minutes); the discussant will synthesize the papers and facilitate a conversation with the audience (30 minutes).

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Interest, Identity, & Empathy

4:20 PM-5:50 PM, Hawthorne/Belmont/Laurelhurst
Presider: Ying-Ting Chiu, The Ohio State University

Using Argument-Based Inquiry to Teach Nutrition in Animals – Impact on Students' Achievement and Interest
Festus Osasumwen Idiaghe, University of Benin
Christiana Nkechi Omoifo, University Of Benin

ABSTRACT
The teaching of Biology has continued to place more emphasis on the transmission of knowledge in a manner that promotes memorization. Due to the demands of the 21st century, some science educators are beginning to emphasize that students in inquiry-based classrooms should not only participate in hands-on laboratory but also be actively engaged in reading, oral discourse, talking and writing. One way to address this issue is to engage students' in scientific argumentation. However, one worries how this will go in societies or communities where students have been brought up not to argue. This study was an attempt to seek if the Argument Based Inquiry (ABI) approach would improve achievement and interest of such students in Biology. The study is a pretest posttest quasi-experimental, non-equivalent control group design. The sample consisted of 86 secondary school class 1 biology students. Biology Achievement Test and Interest Scale was used for data collection. The reliability co-efficient of 0.72 and 0.86 were obtained for the achievement and interest sections respectively. It was found that ABI approach enhanced students' achievement and interest in Biology and that gender had no influence on achievement and interest when taught using ABI approach.

The role of children's racial identity and It's impact on their science education
Lisa M. McDonald, Teachers College, Columbia University
Felicia Moore Mensah, Teachers College, Columbia University

ABSTRACT
To understand young children as learners in science education, this study examined the role that racial identity plays in young children's experiences with science. One goal of this study was to understand how elementary students are situated in the context of their own racial identity as they are fostered into young science Another goal was to examine how racial identity can influence children's approaches to learning science or inhibit their engagement with learning science. Students participants partook in a clinical interview, Likert survey, and photo-elicitation. This study also examined the positive correlation between the socialization of race and science among the children and their families. The participants in this study included 10 children in grades 3 through 5 who attended a diverse urban and their parents (10 parents). Qualitative findings are reported that address the intersections of race, community, and school for elementary children as they navigate their racial and science identities. Correlations between race and science were not found to be dependent on each other. Future research should include examining

in more depth the racial socialization of families and the positionality of teachers and school leaders.

Everyday Engineers: An analysis of youth's everyday engineering practices and identities across settings
Veronica McGowan, University Of Washington
Philip L. Bell, University Of Washington

ABSTRACT
Recent policy documents position engineering as a way to broaden participation for students in STEM fields, noting that engineering gives students the opportunity to deepen their science knowledge by engaging them in problem-solving practices around locally relevant issues. However, a recent literature review of engineering education journals found that less than 1% of reviewed articles focused on equity and broadening participation, so there are few frameworks to build on when designing for culturally responsive engineering instruction. The inclusion of engineering as part of the Next Generation Science Standards opens the opportunity for more students to engage with engineering learning in the classroom and invites research and design work that guide equitable approaches to engineering learning in the classroom that build on students' everyday knowledge, interests, and experiences. During a two-year ethnographic study, we used iterative design-based research methods to construct equitable approaches to engineering instruction for the elementary science classroom that used students' everyday knowledge and experiences to support science learning through engineering design. Our research found that students engaged in authentic engineering practices throughout the many contexts of their lives, and that these experiences could be leveraged to foster student understanding of key science concepts in the classroom.

Development of the Scientific Empathy Index
Heesyn Yang, University of British Columbia
Seong-Joo Kang, Korea National University of Education
David Anderson, University Of British Columbia

ABSTRACT
In this study, the scientific empathy index was developed to measure the factors of scientific empathy that give students motivation to participate in scientific inquiry activities. For this, a draft test tool was developed based on the factors of scientific empathy extracted from prior studies and a preliminary test was conducted. Based on the preliminary test results, the questionnaire was administrated to 1,000 elementary, middle and high school students by checking the validity of the contents and supplementing some of the questions. Confirmatory factor analysis identified that this scale consisted of a total of 26 questions from five factors. Each component was found to consist of a combination of individual and interrelated aspects, and cognitive and emotional processes. In the correlation analysis with other scales related to scientific problem solving, it was confirmed that the scientific empathy index is higher than the general empathy scale in the process of solving creative problems and scientific process skills. In addition, both reliability and validity of the questions on this scale have been shown to be high.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Socioscientific Reasoning, Decision-Making, & Discourse
4:20 PM-5:50 PM, Meadow Lark/Douglas Fir - 3rd floor
Presider: Jean-Philippe Ayotte-Beaudet, Université De Sherbrooke

Multimodal Coherence-seeking in Global Socioscientific Issues-based Discourse
Mary E. Short, The George Washington University

ABSTRACT
This paper discusses a multimodall microanalysis of student discourse during video elicitation interviews focused on global socioscientific issues. Through the analysis, the role of gestures, gaze, body posture and speech moves are illustrated as essential semiotic resources for student coherence-seeking. During conversation, students draw on epistemic, conceptual, social, and physical resources during. In an effort to better understand how students negotiate epistemic authority among themselves, this paper examines middle school students' cooperative accumulative activity of conceptually, and epistemically constructing a representation of the Pacific Gyre. Furthermore, this paper, offers a new approach to conducting research on SSI-based instruction that is grounded in identifying forms of coherence-seeking observed during students' discourse about global SSIs students investigated locally, how coherence-seeking forms are similar or different from those previously discussed in SSI-based literature related to students' reasoning around global ecological SSIs. Specific attention is given to the epistemological, conceptual, linguistic resources students activated, shared, and transformed during conversation.

'I wouldn't want to be the animal nor the patient'– Students' Decision-making on Animal Testing
Carola Garrecht, IPN - Leibniz Institute for Science and Mathematics Education
Ute Harms, IPN - Leibniz Institute for Science and Mathematics Education

ABSTRACT
Although the implementation of socio-scientific issues has been frequently demonstrated as beneficial tool for the promotion of students' decision-making, only a few science teachers incorporate them into their teaching practice regularly. One possibility to assist teachers might be the preparation of certain socio-scientific contexts (i.e., the use of animals in scientific research) and the provision of effective, criteria-based teaching materials. To investigate the potential of animal testing as a suitable context to foster students' decision-making, we conducted an empirical study using a pre-post-test design. We recruited a sample of N=163 students of upper secondary school of whom n=106 participated in a previously developed teaching unit about animal testing (treatment group). The other students (n=57) did not participate in any intervention and functioned as a control group. Both groups completed a previously developed questionnaire with four open-ended items in a pre-post-test which assessed their decision-making. The subsequent analyses revealed that the recognition of the issue's moral relevance and students' provision of arguments for and/or against animal testing improved significantly. Conversely, students did not improve in their ability to anticipate consequences. Our findings suggest that the socio-scientific context of animal testing can be suitable to foster multiple competence dimensions of students' decision-making.

Students' Context-Specific Epistemic Justifications, Prior Knowledge, Engagement and Socioscientific Reasoning in a Mobile Augmented Reality Learning Environment

Hsin-Yi Chang, National Taiwan Normal University
Jyh-Chong Liang, National Taiwan Normal University
Chin-Chung Tsai, National Taiwan Normal University

ABSTRACT

We engaged 47 eighth-grade students in a newly developed learning environment that integrates mobile augmented reality (AR) technology to support students' learning of nuclear energy use and radiation pollution, a topic related to a socioscientific issue (SSI) that involves complex reasoning considering scientific evidence and multiple perspectives. We investigated how the students' context-specific epistemic justification and prior knowledge contributed to their engagement in the learning environment and socioscientific reasoning (SSR) performance after the learning. Data collected include students' responses to the knowledge pretest that assessed students' prior knowledge related to the SSI, the pretest survey that measured students' context-specific epistemic justifications, the Cognitive and Emotional Engagement Survey (CEES) right after the end of the AR activities that measured students' self-reported cognitive and emotional engagement, and the posttest that measured students' socioscientific reasoning performance. To investigate the interrelations among the study variables, we employ PLS-SEM. The results indicate that students' context-specific epistemic justifications can predict their engagement in the environment, and that prior knowledge and one aspect of the context-specific epistemic justifications can predict students' SSR performance. The results provide insights into how to support students with different personal characteristics to learn with AR technology about SSI.

The Effects of Critique-driven Inquiry (CDI) Teaching on Elementary and Secondary School Students' Tendency of Critical Thinking and Scientific Competency

Ying-Yan Lu, National Sun Yat-Sen University
Zuway-R Hong, National Sun Yat-Sen University/Australian Catholic University
Huann-Shyang Lin, National Sun Yat-Sen University/Australian Catholic University
Hsin-Hui Wang, Australian Catholic University
Hsiang-Ting Chen, National Sun Yat-sen University
Kuay-Keng Yang, National Pingtung University
Yi-Ting Pan, National Sun Yat-sen University

ABSTRACT

The purpose of this study was to examine the effects of Critique-driven Inquiry (CDI) teaching on elementary and secondary school students' tendency of critical thinking and scientific competency. Twenty-five 4th graders (EG1) and twenty-eight 7th graders (EG2) were randomly selected from an elementary school and a secondary school in Southern Taiwan to implement a 2-semester CDI teaching. In addition, another 28 4th graders (CG1) and 30 7th graders (CG2) from the same two schools were randomly selected as the comparison groups. All participants completed a Students Questionnaire to measure their tendency of critical thinking and scientific competency. A total of 16 target students from the EG were purposively recruited to be observed weekly and conducted individual interviews at the end of each semester. Both quantitative and qualitative results indicated that EG1 and EG2 students significantly outperformed the CG 1 and CG2 counterparts on tendency of critical thinking and scientific competency across the two semesters. The results add a fresh insight into the mechanism on promoting elementary and secondary school students' tendency of critical thinking and scientific competency. The theoretical and practical implication of these findings are discussed within. Keywords: tendency of

critical thinking; CDI; scientific competency; Taiwan

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

Supporting elementary & early childhood STEM learning

4:20 PM-5:50 PM, Medford

Presider: Justin McFadden, University of Louisville

Promoting elementary students STEM learning by employing engineering design process in the inquiry-based science activity

Kuay-Keng Yang, National Pingtung University
Zuway-R Hong, National Sun Yat-Sen University
Huann-Shyang Lin, National Sun Yat-Sen University

ABSTRACT

The purpose of this study was to explore the effectiveness of students' participated in an engineering design-based activity on their engineering problem-solving performance. A quasi-experimental design with pretest and posttest was conducted with an experimental group and a comparison group (N=19). The framework of intervention focused on the processes of engineering design in a scientific inquiry activity. Experimental group students (N=17) took part in the ten consecutive after school lessons with five different themes of engineering-based activities, and each lesson lasted 2 hours. Both groups of students were asked responding to the engineering-based problem-solving assessment in the pre- and post-intervention to understanding the effectiveness of the intervention study. The statistic analyses of covariance showed that the experimental group students outperform their counterpart on the engineering-based problem-solving test. Besides, the qualitative data analysis from students' worksheets showed that students are gradually capable of sketching a more sophisticated and interpretative design plan. Lastly, the implications of engineering-based STEM activity in science education were discussed.

Prospective Elementary Teachers Plan STEAM Lessons Focused on Science & Engineering

Jaclyn K. Murray, Augusta University

ABSTRACT

This study examines the extent to which prospective elementary teachers (PETs) embed scientific inquiry into design-based STEAM lessons at the elementary level to make the science explicit. We seek to understand the ways in which PETs integrate science and engineering in a design-based STEAM lesson created for elementary students.

Teacher Scaffolding to Support Student Learning in an NGSS-Aligned Unit Integrating Science and Engineering

Sarah Lilly, University of Virginia
Sarah J. Fick, University of Virginia
Anne McAlister, The University of Virginia
Jennifer Chiu, University Of Virginia
Kevin W. McElhaney, SRI International

ABSTRACT
Despite national emphasis on integrating science and engineering core ideas, practices, and crosscutting concepts (NGSS Lead States, 2013), little research has investigated the ways that elementary teachers scaffold this learning through classroom discussions within formal contexts to meet the diverse needs of learners in leveled classrooms. This study explores how teachers verbally scaffold elementary students' engagement with science practices through the learning activities of an integrated science and engineering design project in two classes. Teacher audio data was collected and analyzed. Results revealed that teachers' talk showed similarities between the classes in types of whole-class directed talk; however, the quality of this talk varied for the classes depending on the instructional activity. These results can inform future research on the kinds of supports that teachers need when implementing integrated science and engineering activities in order to move toward providing science learning opportunities for all students.

Teaching STEM Concepts in Elementary School with Biomechanics
Michelle Friend, University of Nebraska at Omaha
Anne Karabon, University of Nebraska at Omaha
Amelia Lanier Knarr, University of Nebraska at Omaha
Kota Takahashi, University of Nebraska at Omaha
Neal Grandgenett, University of Nebraska at Omaha

ABSTRACT
This case study examines the impact on elementary teachers of learning biomechanics as a vehicle for teaching inquiry-based STEM. Nineteen teachers enrolled in a three-week training designed to introduce elementary teachers to biomechanics, the study of the body in motion; help them develop inquiry-based biomechanics lessons; and enhance their implementation of interdisciplinary, culturally responsive, and technology-enhanced STEM education. The professional development deepened teachers' science content knowledge and improved their confidence in teaching science, which impacted their professional knowledge base. Teachers acknowledge the importance of incorporating interdisciplinary approaches to learning science and mathematics yet face a variety of barriers. Challenges include limited access to materials or technology, adhering to mandated district/school curriculum, and their own implicit biases of student capabilities in science and mathematics.

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

Teacher knowledge and implementation

4:20 PM-5:50 PM, Salon D
Presider: Lucia Chacon-Diaz, The Ohio State University

Changing Teacher Practice at Scale through Instructional Routines: Findings from a Field Test of High School Materials
Kiran D. Purohit, New Visions for Public Schools
Dora E. Kastel, New Visions for Public Schools
Elizabeth Chatham, New Visions for Public Schools

ABSTRACT
This paper presents findings from a study on changing teacher practice at the high school level in a large urban district in the United States. In the initial stages of the transition to implementation of the Next

Generation Science Standards, teachers in the study were using NGSS-designed materials for the first time. Through field testing instructional materials from units in Biology and Earth & Space Science, teachers surfaced the ways in which they used, modified, or rejected instructional routines embedded in the materials from these units. Researchers then worked with the teachers to engage in collaborative analysis of their enactment of the curriculum, determining preliminary models for using a routines-driven curriculum model to support shifts in practice at scale, across a network of schools. The findings from this study lay out a direction for the use of instructional routines as a curriculum design tool for phenomenon-driven science teaching and learning.

Science Teachers' Integration of Knowledges and Skills in Enacted Pedagogical Content Knowledge in their Teaching

Imran Tufail, University of Waikato
Chris Eames, University Of Waikato
Cathy Buntting, University of Waikato
Maurice M.W. Cheng, University of Waikato

ABSTRACT
Research on teacher effectiveness has identified pedagogical content knowledge (PCK) as the most significant factor impacting student progress (Neumann, Kind, & Harms, 2019; Park & Chen, 2012) and supported its inclusion in teacher practice (Kind & Chan, 2019), to produce expert teachers rather than content experts (Park, Suh, & Seo, 2018). The Consensus PCK models (Carlson & Daehler, 2019; Gess-Newsome, 2015) have emphasized the importance of classroom practices in understanding PCK. This study investigated the PCK and Skills (PCK&S) of two secondary science teachers during teaching a chemistry unit to Year 10 students in New Zealand. A case study approach was used and data were collected using questionnaires, document analysis, interviews, classroom observation, and video recordings. Questionnaires and interviews focused on teachers’ personal PCK (pPCK) while classroom observations and video recordings captured the enactment of PCK in depth. The findings show that teachers appeared to use an amalgam of two or more knowledges enacted through skills (PCK&S) in teaching practice. Teaching skills are the main element to transfer pPCK into enactment. The educational context and teacher beliefs appeared to act as amplifiers or filters for teachers’ PCK.

The Development of an Instrument to Measure Teachers' Perceptions of STEM Practices

Anthony Sparks, Southern Methodist University
Elizabeth L Adams, Southern Methodist University
Lindsey Perry , Southern Methodist University
Leanne R. Ketterlin-Geller, Southern Methodist University

ABSTRACT
Few surveys currently exist to measure teachers' perceptions of STEM practices. The purpose of the current study is to provide evidence of internal structure for the STEM Perceptions, Practice, and Culture (STEM PPC) survey. Forty-six middle school science teachers in a large urban school district in the southern United States completed the survey over multiple time points as part of a systems level intervention to implement active-learning practices in the classroom. Twenty-seven questions on the survey ask teachers their perceived importance of STEM practices, their confidence in implementing STEM practices, and the frequency of implementation of STEM practices. We hypothesized that higher perceived importance relates to higher confidence of implementation, and higher confidence of implementation relates to higher frequencies of implementation. Our analyses included a multi-level confirmatory factor analysis and multi-level structural equation modeling. Fit indices suggest a

reasonably fitting model for the STEM PPC, providing evidence in support of the hypothesized model. We discuss the implication for STEM education and future research.

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

Postsecondary educators' perceptions, planning, and practices

4:20 PM-5:50 PM, Salon C

Presider: Joshua Reid, Middle Tennessee State University

Classroom discourse patterns of biology instructors in undergraduate STEM classrooms

Petra Kranzfelder, University of California, Merced
Jennifer L Bankers-Fulbright, Augsburg University
Marcos E Garcia-Ojeda, University of California, Merced
Marin Melloy, University of Minnesota
Sagal Mohammed, University of Minnesota
Abdirizak M. Warfa, University of Minnesota

ABSTRACT

Guided by sociocultural theories of learning, we examined the nature of classroom talk moves used by instructors (N = 20) teaching undergraduate biology classes across three institutions as they interacted with their students (N = 2555 students; average class size = 128 ± 50). We used the Classroom Discourse Observation Protocol (CDOP) to capture and characterize classroom talk moves, which we recently developed and validated for quantifying classroom discourse behaviors in undergraduate STEM classrooms. Additionally, we used the Classroom Observation Protocol for Undergraduate STEM (COPUS) to quantify instructional styles. We found that our biology instructors used instructor-centered talk moves (e.g., sharing and evaluating) more frequently than student-centered ones (e.g., constructing and explaining). Also, statistical analyses revealed strong evidence for differences between individual CDOP ($\chi2 = 657.02$, df = 16, $p < 0.001$) and collapsed CDOP ($\chi2 = 162.82$, df = 3, $p < 0.001$) codes, suggesting differential enactment of classroom talk moves. Most interestingly, even though these instructors spent most of their time guiding students through active learning activities, they most frequently used authoritative communicative approaches over dialogical approaches to discuss content. We describe these findings and their implications for undergraduate STEM instruction.

Investigating the Conceptualization and Implementation of Quantitative Reasoning (QR) Skills in Introductory Undergraduate Biology Courses

Ann Cleveland, Maine Maritime Academy
Asli Sezen-Barrie, University of Maine
Gili Marbach-Ad, University Of Maryland

ABSTRACT

Biology increasingly relies on quantitative analysis and mathematical reasoning as the amount and complexity of biological data has surged dramatically with the rapid advances in computing technology. Despite the importance of quantitative reasoning (QR) in biology, students often have difficulty representing data graphically, and articulating data-driven arguments. This study examines how faculty in introductory biology courses conceptualize QR, provide QR instruction and practice, and describe challenges their students face in being successful in QR. We conducted thirteen semi-structured, responsive interviews of faculty from thirteen universities and colleges. The interviews were video-recorded; transcripts of interviews were analyzed in Dedoose, a web application for qualitative data.

Faculty conceptualized QR in one of two ways: operational skills or large-scale conceptual thinking. All faculty included QR instruction and practice in their courses and/or laboratories, despite most having limited awareness of research-based science education pedagogies. Our findings suggest that the community of biology professors lacks a common definition of QR and underscores the importance of implementation of QR in biology courses. This paper contributes first steps towards guiding and supporting faculty as they integrate QR into their curricula.

Pre-Service Early Childhood Teachers' Difficulties in Planning and Implementing STEM-based Lessons
Mustafa S. Topcu, Yildiz Technical University
Ayse Ciftci, Mus Alparslan University

ABSTRACT
This study aims to investigate the difficulties encountered by pre-service early childhood teachers (PECTs) during the planning and implementation process of STEM-based lessons. The research was conducted with qualitative research method. Research was conducted with 39 sophomore PECTs. The open-ended questionnaire, focus group interview, and observation notebooks were used as data collection tools. The content analysis method was preferred for data analysis. At the end of the analysis, regarding the problems encountered in the planning process of STEM-based lessons, 5 themes were revealed: Identifying the problem, group work, children's development level, material selection and STEM integration. Regarding the implementation process, 6 themes were identified: Expressing the problem, group work, targeted instruction & implementations, children's development level, time management, and classroom management. It is important to detect the problems encountered by PECTs in the planning and implementation process of STEM-based lessons to overcome these problems.

The Effects of Flipping STEM Classrooms on Instructional Practices
Robert Idsardi, Eastern Washington University
Ivy Tietsort, Eastern Washington University
Jennifer Mancinelli, Eastern Washington University

ABSTRACT
The implementation of active-learning instructional approaches is one way to improve undergraduate student learning in STEM disciplines for all students. Active-learning instruction can vary widely. One increasingly popular active-learning approach is the flipped classroom approach. It is currently unknown how faculty implementing this approach use in-class time, and how variations in the flipped classroom approach influence student learning. This paper presentation will describe the various ways undergraduate STEM faculty implemented the flipped classroom approach following the same professional development workshop using classroom observation data. The research question guiding this study was in what ways do STEM faculty implement the flipped classroom approach following the same professional development experience? Researchers video recorded STEM faculty flipped and non-flipped courses, and coded videos using the Classroom Observation Protocol for Undergraduate STEM (COPUS). Findings reveal the flipped classroom approach allowed faculty to lecture less during class than in non-flipped courses. This allows students more time to solve problems and answer questions. The paper presentation will include descriptions of the various ways faculty implemented these changes. These findings will inform STEM professional development facilitators take into account the various ways novice active learning instructors will implement teaching innovations.

Strand 6: Science Learning in Informal Contexts
Educating informal science educators
4:20 PM-5:50 PM, Salon E & F
Presider: Brenda L. Carpenter, Lower Columbia College

Analyzing Contradictions in Project-Based Learning Internships from the Cultural–Historical Activity Theory Perspective
Pei-Ling Hsu, University Of Texas At El Paso

ABSTRACT
Project-based learning (PBL) has been suggested as an effective way to engage students meaningfully in science learning. However, many challenges occur in PBL (e.g., difficulty of assessing learning, uncertainty of teaching process). This qualitative study investigates how cogenerative dialogues (cogens) might serve as a pedagogical tool to enhance the quality of PBL in a university science internship for high school students. Data sources include video recording of the internship and cogen activities, field notes, pictures, student journals, and individual interviews. Drawing on cultural–historical activity theory, our analysis suggests that cogens are a useful tool to help high school students and scientists address contradictions encountered in the process of teaching and learning in PBL.

How does a STEM Outreach Event Impact Scientists' Communication Objectives?
Stephanie D Teeter, NC State University
Jacqueline H Cole, NC State University

ABSTRACT
In this study, we examined the motivations of scientists who participated in an outreach event. We created surveys based on existing science communication research that assessed what types of motivations scientists prioritized, how important they felt the objectives enumerated in science communication literature were, as well as if the event had any impact on these priorities or if the scientists gained anything from the event. Based on both paired and unpaired pre- and post-event surveys, we found that the goals of these university scientists largely mirrored the objectives in the literature. Their top priorities included boosting interest and excitement in science and humanizing scientists. Less important were goals such as affecting policy change or conveying competence. Scientists did not feel they gained a great deal from this event, only slightly agreeing with statements regarding gaining insight into people’s concerns about science or gaining insights from participants. However, they did feel that they learned as much from participants as the participants learned from them. These findings can hopefully add to the existing but very limited literature on why scientists engage in outreach and can help educators to understand why scientists engage in outreach and facilitate their efforts.

iPCK: Developing a Framework for Pedagogical Content Knowledge for Informal Science Educators
K.C. Busch, North Carolina State University
Mwenda Kudumu, NC State University
Soonhye Park, North Carolina State University

ABSTRACT
Many people associate learning with school; however, the average individual spends less than 5% of their lifetime in school (Falk & Dierking, 2010). In contrast, the landscape of informal science learning

opportunities is expansive, including museums, zoos and aquaria, hobbies, and everyday contexts (NASEM, 2016; NRC, 2009). However, little research exists about the characteristics of an effective informal educator. Specifically, what are the knowledge, attitudes, and skills that are most needed to be an accomplished informal science educator? To address this gap in the field, the aim of this research was to create a framework of PCK for informal educators (iPCK).

Teacher Learning through Participation in an Outreach Program to Link Field Trips with Classroom Curriculum

Alexandria Muller, University of California at Santa Barbara
Victor Corona, University of California at Santa Barbara
Ron Skinner, MOXI, The Wolf Museum of Exploration + Innovation
Tarah Connolly, MOXI, The Wolf Museum of Exploration + Innovation
Danielle Boyd Harlow, University Of California At Santa Barbara

ABSTRACT
Field trips have a positive impact on cognitive development of youth; however, this impact is relatively small due to the brief nature of the visits. The use of pre- and post-visit activities in conjunction with a field trip can extend the effects of the field trip. Unfortunately, teachers are ill-prepared to teach science and engineering within their classrooms making pre- and post-visit activities less likely to occur. To combat this, we have developed Explore Engineering (pseudonym), a program linking classroom curriculum to engineering field trips to an interactive science museum. Through this program, we have provided opportunities for teachers to develop expertise and confidence through the materials designed for classroom use. This paper explores what first through sixth-grade teachers have learned from participating in this program.

Strand 7: Pre-service Science Teacher Education

Accessing Funds of Knowledge to Enhance Instruction

4:20 PM-5:50 PM, Salon A

Presider: Sibel Erduran, University of Oxford

Preservice Science Teachers' Understanding of Instruction for Diverse Learners: A Focus on Funds of Knowledge

Stacey L. Carpenter, University of California - Santa Barbara
Erik Arevalo, University of California - Santa Barbara
Meghan Macias, University of California - Santa Barbara
Alexandria K. Hansen, Fresno State University
Leslie Bushong, University of California - Riverside
Susann Pinter, University of California - Davis
Elisa M. Stone, University of California - Berkeley
Julie A. Bianchini, University Of California - Santa Barbara

ABSTRACT
In this mixed-methods study, we addressed the critical challenge of how to prepare novice teachers to effectively teach reform-minded science in culturally and linguistically diverse classrooms. We analyzed survey and interview data to examine how 69 preservice secondary science teachers from three teacher education programs understood four principles of effective science instruction for diverse learners: (1) building on students’ funds of knowledge and other resources, (2) engaging students in cognitively

demanding work, (3) providing students with rich language production opportunities, and (4) attending to academic language demands and supports. We focused on how participants conceptualized the principle of building on students' funds of knowledge and other resources, as well as how these conceptualizations intersected with the other three principles. Our findings indicate areas where science teacher educators can better support preservice teachers, such as with making connections to students' cultural backgrounds and community resources, drawing on students' linguistic resources to support academic language beyond vocabulary terms, and recognizing the funds of knowledge students have to engage in the cognitively demanding work of science and engineering practices.

Funds of Knowledge in Making: Re-envisioning Maker Education in STEM Teacher Preparation
Myunghwan Shin, California State University, Fresno
Jane J. Lee, Michigan State University

ABSTRACT
As the maker movement grows, researchers have become increasingly interested in introducing maker education in K-12 schools to boost student engagement and learning in STEM. However, significant questions remain concerning the learning experiences or supports offered by teacher preparation programs that may facilitate preservice teachers' understanding of equitable maker education and their implementation of inclusive making activities in school classrooms. This study explores how preservice elementary teachers participated in STEM-focused making by utilizing their funds of knowledge in a STEM education university course. This study seeks to understand how preservice elementary teachers' use of their funds of knowledge for making influenced their perspectives on maker education. Guided by the theory of funds of knowledge and the ethnographical research method, we analyzed multiple qualitative data of 15 preservice elementary teachers collected through participant observation, interviews, and artifact collection. The findings show that preservice elementary teachers utilized their diverse funds of knowledge for making in ways that 1) redefined the purpose of making, 2) validated diverse epistemic authority, and 3) positioned themselves as critical maker educators. This study contributes to expanding the discourse about how teacher education programs can support preservice teachers in implementing equitable maker education in K-12 classrooms.

Attention to Students' Cultural Funds of Knowledge within Pre-service Teachers' Lesson Plans
Kirby Whittington, Florida State University
Miray Tekkumru Kisa, Florida State University
Sherry A. Southerland, Florida State University

ABSTRACT
Research has continually called for teachers to integrate aspects of students' cultural funds of knowledge as a means to bridge the gap between students' home and lived experiences with that of learning science. The University of Michigan's high leverage teaching practices notes that designing instruction based on students cultural and religious backgrounds is a critical practice for pre-service teachers given its benefit to students in the classroom. Based on this critical practice, this exploratory study looks at how pre-service teachers are integrating aspects of students' cultural funds of knowledge within the curriculum they design. We looked at the lesson plans submitted by seven pre-service science teachers during their full-time teaching internship for different aspects of culture that could be attended to including home or community, everyday reasoning, and student interest. Preliminary findings revealed that most of the lessons pre-service teachers design do not attend to students' culture or lived experiences. When these lessons did attend to cultural funds of knowledge, this was most often done

through attention knowledge students had about their particular city or state. Based on these findings we discuss implications for lesson design and teacher education programs.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers' Identities and Beliefs
4:20 PM-5:50 PM, Salon B
Presider: Ryan Coker, Florida State University

"More than I thought I would"- Effect of an NGSS-aligned Biology Content Course on Pre-Service Elementary Teachers' Self-Efficacy and Related Self-Perceptions
Darcy M. Ronan, Sacred Heart University

ABSTRACT
Recognizing the relationship between self-efficacy and self-perceptions of content mastery and their impact on elementary teacher's attitudes, beliefs, and likelihood to teach science, this study explores the impact of a biology content course designed specifically for aspiring elementary teachers, in alignment with the K-5 NGSS for Life Science. Students in Biology for Elementary Educators participated in a pre- and post- survey designed to measure self-efficacy (STEBI-B) and self-perceptions of content mastery. Qualitative findings regarding pre-service teacher attitudes and beliefs about science and science-teaching drawn from surveys, interviews, and focus groups revealed interrelationships among self-efficacy, past experiences, self-perceptions, and gains in understanding and skills that the participants attribute to their experience in the course. While not a methods course, Biology for Elementary Educators emphasized the integration of DCI and SEP, especially in assessments. Course projects applied DCI and SEP to the science thinking of children and the exploration of the local science community.

Preservice Elementary Teachers' Science Teacher Science Teaching Beliefs: Influence of Science Learning and Teaching Experiences
Saiqa Azam, Memorial University Of Newfoundland
Deepika Menon, Towson University

ABSTRACT
This mixed-methods research investigates changes in preservice elementary teachers' science teaching beliefs within the context of a science methods course. A total of 55 preservice elementary teachers participated from two public universities located in the United States and Canada. Supported by the theoretical underpinnings of teacher beliefs and drawings as a tool to investigate teacher beliefs, this research utilized quantitative (Draw-a-Science-Teacher-Test-Checklist as a pre and post measure) and qualitative (written science autobiographies and reflections) data collection techniques. The statistical results from the analysis of pre and post-DASTT-C scores indicated significant positive shifts in preservice teachers' beliefs regarding science teaching after their participation in the science methods course. The change in science teaching beliefs was quantified and categorized in low and high shift groups. The qualitative data analysis for these two groups of participants (low-shift and high-shift) present similarities and difference in the ways they interpret their science learning and teaching experiences at the time of entering and completing the science methods courses.

Exploring How Early Classroom Teaching Experiences Help Develop a Teacher Identity in Undergraduate Science Students

Megan Beckam, University of Nevada, Reno
Mandi Collins, University of Nevada, Reno
Elizabeth X. De Los Santos, University of Nevada, Reno

ABSTRACT
This qualitative study explored if and how early classroom teaching experiences influenced the ways undergraduate science students think of themselves as future science teachers. Identity development was used as a lens to understand how these teaching experiences influenced participants' views of themselves and their beliefs. In general, participants found that early field experiences were fulfilling and surprising, developed their confidence and vision as a future science teacher, and described the important roles of mentor teachers and reflection in a community of learners. This study contributes empirical evidence to the research base in understanding how specific and early classroom experiences can influence secondary science undergraduates' identity formation as future science teachers.

Preservice Elementary Teachers' Identity Development in Learning to Teach Science: A Multi-site Case Study

Deepika Menon, Towson University
Saiqa Azam, Memorial University Of Newfoundland

ABSTRACT
The purpose of this study is to examine preservice teachers' development of science teacher identity in light of formal K-12 school science and informal experiences, and college science methods course and field experiences. Data were collected from the two research sites, at a large mid-Atlantic public university in the United States and a Canadian University over more than a year. We utilized a case-study design and a theoretical framework of "Learning to Teach" to guide this investigation. Data collection sources included: individual written science autobiography and an open-ended demographic questionnaire at the beginning of the course, written reflections on field-teaching, teaching observations and artifacts, and one semi-structured interview towards at the end of the final semester of their program. Data analysis was ongoing, and we used memoing throughout this year-long study, as well as open and axial coding to generate themes. Findings indicate that while K-12 and life experiences are essential sources towards the development of teacher identity, new and fresh experiences gained during the preservice teacher preparation courses provides the knowledge and skills that collectively contribute towards "Learning to Teach," which can bring lasting effects on the development of identity. Implications for preservice teacher preparation are discussed.

Strand 8: In-service Science Teacher Education
Engineering Practices to Support NGSS
4:20 PM-5:50 PM, Pearl
Presider: Nidaa Makki, The University of Akron

A Mixed Methods Study of the Impact of Engineering PD on Teachers' Motivation & Practices

Nidaa Makki, The University of Akron
Kristin L. Koskey, The University of Akron
Wondimu Ahmed, The University of Akron
Tania Jarosewich

Donald P. Visco, The University of Akron
Nicholas Garafolo, The University of Akron

ABSTRACT
This mixed methods study examined the impact of teacher professional development focused on integrating technology and engineering design into the Middle School science curriculum on teachers' knowledge, self-efficacy, and implementation practices. With curriculum materials integrating engineering design being developed to align with NGSS, there is a need to examine how professional development opportunities can support teachers in learning about engineering design and how to implement it in their classrooms. Findings suggest that sustained professional development that focuses on engaging teachers in technology rich engineering design activities, with substantial follow up during the school year can improve teachers' knowledge and practices. Challenges reported by the teachers in the study will be shared.

Fourth Grade Feelings– Elementary teachers' affective experiences in authentic engineering tasks
Merredith D. Portsmore, Tufts University
Jessica Watkins, Vanderbilt University
Rebecca D. Swanson, Tufts University

ABSTRACT
The growing presence of engineering in K-12 education has led to increased attention on teacher education. Standards and research alike call for teachers to be involved in the "doing" of engineering. However, there is little detail or evidence about what that entails or its implications for teacher learning. In an online teacher education course in engineering, designed for elementary educators, we tested a conjecture that engaging teachers in rigorous engineering challenges designed for adults (termed "authentic engineering") would support teachers' conceptions about engineering design. In post-course interviews with teachers an unanticipated theme emerged as teachers reported affective experiences and empathy for their students as one of the significant learnings they took from the hands-on engineering projects in the course. The impacts of authentic engineering on teachers in the affective dimension has potential implications for pedagogical reasoning as well as design principles for teacher education experiences.

NGSS Teacher Professional Development to Implement Engineering Practices in Science Instruction
Kimberly B. Christian, Stony Brook University Smithtown High School East
Angela M. Kelly, Stony Brook University
Monica F. Bugallo, Stony Brook University

ABSTRACT
This quasi-experimental, observational study reports the design and implementation of an NGSS-based professional development workshop series for middle and high school teachers focusing on science and engineering practices. The workshop structure was based upon the knowledge integration perspective of cognition, whereby students may draw connections between learning in different contexts. University-based science and engineering faculty developed a series of engineering modules in 1) electrical engineering and physics, 2) biotechnology and biology, and 3) educating teachers on the diversity of engineering disciplines and preparing students for post-secondary engineering study. Science and mathematics teachers (n=37) voluntarily participated in the workshops and completed pre- and post-surveys. Comparisons of means revealed the participating teachers reported statistically large improvements in their ability to: 1) use engineering activities in the classroom effectively, 2) increase

students’ interest in engineering, 3) help students apply engineering to real-world situations, and 4) advise students on different engineering disciplines and careers, as well as how to prepare for them before college. The results from this study demonstrate that a university-based professional development workshop series is an effective intervention to improve the engineering knowledge and skills of secondary STEM educators, ultimately increasing NGSS adoption in classroom instruction.

Strand 8: In-service Science Teacher Education

Professional Development to Support Curriculum Design

4:20 PM-5:50 PM, Columbia

Presider: Gayle N. Evans, University of Florida

Storytelling for Collaborative STEM Curriculum Development: Negotiating Discourses of Play and Learning

Charlene L. Ellingson, Mankato State
Sue Staats, University of Minnesota
Gillian H. Roehrig, University of Minnesota

ABSTRACT

Drawn from a larger study that examined the collaborative redesign of integrated STEM curriculum, this paper uses narrative discourse analysis to explore how teacher design teams used storytelling as a resource for negotiating their understanding of integrated STEM curriculum. As teachers shared stories of their curriculum implementation during curriculum redesign sessions, they duplicated elements of story structure in their mode of speaking that the study terms “parallel storytelling.” Through parallel storytelling, they negotiated central issues in science education such as learning, play, assessment, and the relationship amongst themselves. Sharing stories during post-implementation sessions helped the team to bridge the gap between their classroom design activity (interpreting, selecting and implementing curriculum) and their curriculum design activity (curriculum organization). The purpose of this paper is to demonstrate the nature of parallel storytelling and how it functioned as a collaborative resource for STEM Pedagogical Design Capacity (PDC) development.

Supporting Teachers' Vision of Science Instruction through Professional Development for Reform-Based Curriculum Materials

Katherine L. McNeill, Boston College
Renee Affolter, University of Massachusetts - Amherst
Benjamin R. Lowell, Boston College
Casandra Gonzalez, Boston College
Kevin Cherbow, Boston College

ABSTRACT

The shifts called for in recent reform efforts and science standards require new roles for students and teachers. To support these changes in k-12 classrooms, most teachers will need to alter the way they teach and require professional development (PD) to support these changes. In this study, we investigated the impact of PD on teachers’ beliefs and confidence about recent shifts in science instruction. Specifically, we worked with 30 teachers during a four day in-person professional workshop designed to support their enactment of reform-based curriculum. We collected multiple data sources including: pre and post surveys, post interviews and video recordings of all PD sessions. Our research suggests that PD that utilizes curriculum materials designed with these key shifts in mind can help

support changes in teachers' beliefs about science instruction. Teachers' vision of science shifted towards one in which the teacher was no longer pre-teaching vocabulary or engaging students in disconnected hands-on activities to one in which students were figuring out the science ideas over time as they engaged in sensemaking. Although we observed important shifts in teachers' beliefs, we did not see significant changes in their confidence to enact these in their classrooms.

PD for Middle School Science Teachers for Integration of 3D Learning using NASA Education Resources
SoonChun Lee, Wichita State University
Daniel Bergman, Wichita State University
Greg Novacek, Wichita State University
Cathy Durano, Wichita State University

ABSTRACT
The workshop, *** (project name blinded), aimed to expand the use of NASA's Education programs and resources to effectively assist middle school science teachers in meeting the space-sciences standards recommended by Next Generation Science Standards. The workshop and curriculum are designed to enhance the teachers' content knowledge, skills, and teaching practices to capture the interest of their students, and to channel that interest into related career paths through the integrated applications of space-sciences, mathematics, technology, and engineering recommended in the NGSS. The workshop has two phases: (1) a 3-day summer workshop to learn and practice space-science lessons, and (2) implementing the space-science lessons in the classrooms with STEM coaches' assistance. The students of the participant teachers were also engaged in the space-science lessons over 3 – 4 weeks during the following school year. The teacher measures showed the significant impact of the workshop on teachers' knowledge in space-sciences, confidence in teaching a space-science lesson, and utilizing the NASA Education resources. The workshop demonstrated an effective PD that middle school science teachers are equipped with the skills and confidence in utilizing the NASA education resources for their space-science lessons.

Strand 10: Curriculum, Evaluation, and Assessment
Novel Approaches to Science Assessment
4:20 PM-5:50 PM, Salon I
Presider: Xiaoming Zhai, Michigan State University

A Framework to Conceptualize Machine Learning-based Science Assessments
Xiaoming Zhai, Michigan State University
Kevin C. Haudek, Michigan State University
Lehong Shi, East Lansing
Ross H. Nehm, Stony Brook University - SUNY
Mark Urban-Lurain, Michigan State University

ABSTRACT
This study develops a framework to conceptualize the use and evolution of machine learning (ML) in science assessment. We systematically reviewed 47 studies that applied ML in science assessment. We compared the ML-based and conventional science assessments and extracted 12 characteristics that are critical to map three variables (i.e., Construct, Assessment Functionality, and Automaticity) in a three-dimensional framework. The 12 characteristics that made a profile for ML-based science assessments in each article, were further analyzed by a two-step cluster analysis. The clusters identified within each

variable were summarized into four levels to illustrate the evolution of each variable. We further conducted cluster analysis to identify four patterns across the three variables. Based on the analysis, we conclude that ML has transformed, but not yet redefined, conventional science assessments in terms of fundamental purpose, the nature of the science assessment, and the relevant assessment challenges.

Accessible NGSS Assessment: Technology-Based Innovative Methodologies for Multidimensional Teaching and Learning

Heather K. Harkins, University of Wisconsin-Madison
Laura J. Wright, University Of Wisconsin-Madison
Rebecca Kopriva
Linda Malkin, University Of Wisconsin-Madison
Blake Myers, University Of Wisconsin-Madison
Ellyssa Eiring, University Of Wisconsin-Madison

ABSTRACT

ONPAR is a U.S. Department of Education funded project to develop computerized classroom assessment of student understanding in science and mathematics that supports teaching. These assessments use engaging multi-media content to reduce accessibility barriers for students and sophisticated scoring algorithms to provide users with immediate and useful diagnostic feedback meant to inform instruction. ONPAR is designed to integrate into existing classroom curriculum using the latest standards, including the Next Generation Science Standards (NGSS). Drawing from linguistics and semiotic theory, ONPAR capitalized on the affordances of online technology to create a grammar for assessment design. This culminated in 36 online tasks which assessed middle school NGSS life, chemical, physical and Earth science content. This paper examines the results of a large-scale study of the ONPAR science tasks, paying close attention to the task revision process based on these results.

Designing Crosscutting Concepts Assessments to Support NGSS Teaching and Learning

Lei Liu, Educational Testing Service
Dante Cisterna, Educational Testing Service
Cindy E. Hmelo-Silver, Center for Research on Learning & Technology
Abeera Rehmat, Indiana University
Karyn Housh, Indiana University
Shu-Kang Chen, ETS
Peter van Rijn, Educational Testing Service
Aurora Edith Graf, Educational Testing Service

ABSTRACT

Crosscutting concepts (CCCs) are essential conceptual tools for scientists to organize their ideas and make sense of natural phenomena across the science disciplines. Such conceptual tools can help students make sense of new concepts and tackle novel problems in new contexts or situations. A Framework for K-12 Science Education (NRC, 2012) and the Next Generation Science Standards (NGSS, 2013) emphasize that Crosscutting Concepts are valuable tools for developing, understanding, and connecting Disciplinary Core Ideas and Scientific and Engineering Practices across students' learning experiences. However, there has been a gap in existing science assessments that explicitly measure the CCCs. Our research begins to address such a gap by developing and validating assessments that measure the CCCs. We developed hypothesized learning progressions (LPs) and evidence-centered design framework to guide the development of these assessments. Our focus on CCCs does not diminish the value of DCIs or SEPs, but rather highlight the need for science educators to attend to CCCs explicitly. In

our research work, we developed hypothesized LPs for two CCCs to guide the developing new assessments for middle and high school students across different science contexts, instruments for validating LPs.

Understanding external expert review of design artifacts in design-based research: A guide for the perplexed
Gary Weiser, WestEd
Brian D. Gane, University of Illinois at Chicago
Christopher J. Harris, WestEd
James Pellegrino, University of Illinois at Chicago
Sania Z. Zaidi, University Of Illinois - Chicago

ABSTRACT
External expert review panels (or EERPs) have a long history in the design of educational artifacts in science – including assessments, curricular tools, and textbooks. Among assessment developers, EERPs are commonly used to receive feedback in support of a claim of content validity – often focusing on item fairness and appropriateness. However, content validity is only one component of what ought to be a many-facetted validity argument. Using EERPs in this narrow way acts to the detriment of other forms of content validity evidence and of other components of a validity argument that EERPs might support. In our work designing and researching instructionally supportive, three-dimensional assessment tasks aligned to the Next Generation Science Standards, we have explored using EERPs to support cognitive and instructional validity in addition to content validity. In this paper, we describe the role EERPs can play in helping designers reflect and receive feedback on these components of validity along different phases of the design process. Using examples from our own assessment design work, we discuss the practical concerns for implementing an EERP such as introducing design artifacts, receiving feedback about those artifacts, and translating that feedback into improvements in the validity of the artifact.

Strand 11: Cultural, Social, and Gender Issues
Establishment and Maintenance of Black STEM Community Institutions
4:20 PM-5:50 PM, Salon H

Establishing a Black STEM Expert Community during the 20th Century
Charnell Long, University of Wisconsin-Madison

Exploring STEM Afro-Futurites through the Narratives of HBCU Educated Black Women Scientists
Reanna S. Roby, Michigan State University

And Her Name is Me: Insight Behind the Meaning of Being a Black Woman in Undergraduate STEM Education
Terrell R. Morton, University of Missouri - Columbia

Creating a Culturally Relevant Digital Sphere for Black and Brown Youth
Justin Shaifer, Columbia University

ABSTRACT
The need for STEM community institutions or intergenerational spaces were people of color can engage with science concepts is essential for the recruitment, retention, and promotion of future

generations. Although the science education community has discussed the importance of public community institutions- like museums, zoos, and parks- research on spaces designed by and for people of color is limited. The papers in this panel utilize historical and qualitative methodologies to assess how people of color negotiate space in STEM education. Papers cover the establishment of Beta Kappa Chi Scientific Honor Society as a counter-public for Black students to thrive as scientific researchers, Black Women scientists' epistemologies at Historically Black Colleges and Universities (HBCUs), how Black undergraduate women conceptualize STEM through their own identity embodiment, and the creation of culturally relevant STEM spaces for students of color. Individually and as a group, these papers grapple with the ways people of color approach, examine, dissolve, and redraw boundaries—both in terms of demarcations of exclusion, but also as lines maintaining inclusivity within communities strengthened by common bonds of experience, oppression, and expertise—to engage with their science generation and education.

Strand 11: Cultural, Social, and Gender Issues

Renegotiating Multiculturalism & Multilingualism in Science Education

4:20 PM-5:50 PM, Salon G

Presider: Bhaskar Upadhyay, University of Minnesota

Addressing Cultural Validity in Science Assessments for English Learners: A Guiding Framework

Preetha K. Menon, Stanford University

ABSTRACT

This paper addresses the need for enhanced assessment systems that contribute to more valid and fair testing for English learners (ELs) in science. Drawing from the sociocultural perspectives of multimodality, assessment for learning and systemic functional linguistics, I created a framework to address assessment development and use with a focus on cultural validity. The framework discerns ways to a) guide the assessment process, b) identify constructs which influence students' responses and c) identify ways to modify the assessments. It can be applied by teachers and researchers to guide the overall process of development, review and use of multimodal science assessments in linguistically diverse science classrooms. Test developers can use this framework to improve validity and fairness through enhancing their test development and review process, and teacher guidance efforts.

An Apprenticeship Model for Culturally Responsive STEM Research in Pacific Island Cultures

Tobias Irish, University of Hawaii at Hilo
Joseph Genz, University of Hawaii at Hilo
Cheryl Sangueza, University of Guam
Marata Tamaira, University of Hawaii at Hilo
Dwayne Anefal, University of Hawaii at Hilo
Yubee Isaac, University of Hawaii at Hilo

ABSTRACT

This study addresses issues related to the underrepresentation and lack of persistence of Pacific Islanders in STEM fields by using as a case study the experience of two apprentice researchers, both of Pacific Islander decent and upbringing, who navigated their own engaged participation in a research project in which they were both researchers and subjects of the research. The apprentices participated as full members of a research team for the period of a year and were involved in the development, implementation, and analysis of culturally responsive research protocols. Throughout the process the

apprentices produced personal narrative reflections on their own cultural identities and understandings and relayed their experience of being participants in the research project. The results of the case study reveal that for the students, choosing a career pathway in STEM is deeply rooted in a sense of responsibility and commitment to their home communities as well as to the land and its natural resources. We argue that such insights can be used to better inform STEM programs and employers about the unique sociocultural factors that influence Pacific Islanders who pursue STEM careers so that they can provide opportunities that are seen as relevant and meaningful.

An Asset-based Introduction to Multilingualism: Effects on Student Attitudes and Beliefs About Science
Catherine Lemmi, California State University, Chico

ABSTRACT
United States classrooms are sites of rich linguistic diversity, but often science classrooms do not draw on that diversity as a resource for learning. This study reports the results of an intervention that examined the impact of making 6th-12th grade science students aware of their linguistic resources and inviting them to view their language backgrounds as an asset to learning. The treatment group reflected on their own linguistic resources, while the control group reflected on science language. Findings revealed statistically significant differences in students' beliefs about their own ability to succeed in science and the positive influence of science on the world between the treatment and the control groups.United States classrooms are sites of rich linguistic diversity, but often science classrooms do not draw on that diversity as a resource for learning. This study reports the results of an intervention that examined the impact of making 6th-12th grade science students aware of their linguistic resources and inviting them to view their language backgrounds as an asset to learning. The treatment group reflected on their own linguistic resources, while the control group reflected on science language. Findings revealed statistically significant differences in students' beliefs about their own ability to succeed in science and the positive influence of science on the world between the treatment and the control groups.

Formative Interventions for Expansive Teacher Learning in Multilingual Science Education: Change Laboratories for Practice Transformation
Sara Salloum, University of Balamand
Saouma B. Boujaoude, American University Of Beirut
May Antoun, University of Balamand

ABSTRACT
Vygotsky's sociocultural perspective views language as a mediating artifact central to meaning-making in science education. In multilingual settings, role of language is even more prominent, as scientific content can be challenging to language learners, who face demands of learning science through an unmastered language with little instructional support and without full deployment of their whole communicative repertoires. The aim of this paper is to examine the initial phases of an ongoing 'formative intervention' with two Lebanese schools attempting to build their capacity for enhancing both conceptual science learning and language proficiency. 'Formative interventions' are facilitated through change laboratory meetings for teachers and researchers' to uncover contradictions in practice and develop new tools to address them. Bakhtin's notion of dialogicity was used to examine teachers and the researchers' interactions during the initial Change Laboratory (CL) meetings as a 'dialogic' space for teachers, teacher leaders, and researchers to explore research-based notions alongside professional practical knowledge. Five questions on role of language and language-in-education policy were introduced. Interactions within the CL were analyzed to discern frequency of monologic and dialogic

statements. Frequencies were compared across the two schools and the different questions. Implications for future CLs and capacity-building activities are discussed.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Learning of NOS
4:20 PM-5:50 PM, Portland
Presider: Isha DeCoito, Western University

International Collaborative Investigation of Third Grade Students' Understandings of Scientific Inquiry
Judith S. Lederman, Illinois Institute Of Technology
Norman G. Lederman, Illinois Institute Of Technology
Selina L. Bartels, Valparaiso University
Juan Jimenez, Illinois Institute of Technology

ABSTRACT
Although understandings of scientific inquiry (as opposed to conducting inquiry) is included in science education reform documents around the world, little is known about what students have learned about inquiry during their school years. Over the past few years studies have been conducted on both middle and high school students' understandings of Scientific Inquiry. A study looking at elementary students' understandings of scientific inquiry is the natural follow up to the previous studies. However, a valid and reliable assessment tool for younger students was not available until now. The purpose of this large scale (i.e.,35 countries spanning six continents and including over 5,000 students) international project was to get data on what elementary school students' beginning understandings of scientific inquiry. This study will examine elementary students' understandings of scientific inquiry and obtain a baseline of where students begin to shape a critical piece of understanding for scientific literacy. This study rounds out the work of the previous two studies and allows for a full picture of scientific inquiry understandings from elementary school through high school.

Talk is cheap: Could changing our metaphors of teaching and learning actually help enhance our teaching?
Glenn Dolphin, University Of Calgary

ABSTRACT
The proposition put forward in this paper comes from recent research in philosophy of education, cognitive science, and the history and philosophy of science. Learning takes place through embodied experiences. The learner then uses these concrete experiences to give meaning to abstract concepts, through the use of metaphor. Because communication is done almost exclusively via metaphor, and these metaphors unconsciously impact our perceptions through a "cascade of association" or "experiential gestalt", the metaphors we use for teaching and learning impact how we do them. Metaphor has impeded scientific progress as well as helped advance it. The family of metaphors we use to describe communication (the conduit metaphor) has such an impact on those involved in communicating. Further, because teaching is a form of communication, manifestations of the conduit metaphor not only reveal how teachers and students understand teaching and learnin but also serve to reinforce the transfer model of education, lecture, where the student acquires simply a vocabulary. Finally, having demonstrated the effect of the conduit metaphor (and its related entailments) on perceptions of teaching and learning, I will explore changing the metaphor. Could more effective teaching come about merely by changing the way we talk about teaching and learning?

Undergraduates' Grounded Critique of Knowledge Claims in Socioscientific Decision Making

Won Jung Kim, Michigan State University
Alicia C. Alonzo, Michigan State University

ABSTRACT
Reasoning about SSIs entails values, knowledge claims, and potential decisions. This study seeks to capture the practice of evaluating knowledge claims to make socioscientific decisions, calling this practice grounded critique. Utilizing grounded theory in continuous dialogue with relevant literature, we conceptualize grounded critique by analyzing undergraduate students' reasoning as they evaluate and make decisions about socioscientific issues presented in scenario-based interviews. Taking the construct frame as our conceptual framework, we propose the construct grounded critique as cautious examination and weighing of knowledge claims to make decisions using multiple frames drawing on (i.e., grounded in) epistemic and axiological resources. Students exercise grounded critique by drawing on ideas about knowledge and knowing and on values activated in the context of examining knowledge claims (i.e., epistemic/axiological resources) with openness to evaluating different claims as trustworthy or untrustworthy (i.e., epistemic caution) and openness in weighing claims to make potential decisions (i.e., axiological caution). Here, frames are formed as networks of activated resources. We suggest that researchers and educators engage students in socioscientific decision making and encourage students to develop resources and to exercise epistemic and axiological caution in the flexible use of multiple frames for evaluating and weighing relevant knowledge claims.

Strand 14: Environmental Education

Environmental Education - learner's perspective

4:20 PM-5:50 PM, Eugene

Presider: Alexandra T. Gillis, Brooklyn College

Developing Socioscientific Perspective Taking

Mark H. Newton, East Carolina University
Dana L. Zeidler, University Of South Florida

ABSTRACT
Perspective taking has been identified as a critical skill in the development of scientifically literate citizenry. Despite the importance of the construct, operationalizing and identifying effective pedagogical strategies to promote effective perspective taking have proven challenging. This study provides empirical evidence to support the theoretical Humanities, Arts, and Social Sciences model for identifying effective perspective taking interventions in the science classroom. A modified perspective reading and writing intervention was imbedded within a postsecondary environmental science course examining the management of wolves in North America. Participants demonstrated more nuanced abilities to consider various perspectives and recognize the complexity of managing wolves in Northern California.

Environmental education as a chance to foster the motivation towards learning science?

Mona L. Schönfelder, University of Bayreuth
Franz X. Bogner, University Of Bayreuth

ABSTRACT
Science education and environmental education are essential instruments facing ‘wicked’ challenges of today’s society. On a formal level, environmental issues are embedded in science education within an interdisciplinary context. As both educational efforts traditionally bear different emphases, the question may come up whether formal science classes can act as appropriate hosts for environmental education. Against the background of the declining motivation to learn science in secondary school, we aim to focus on possible synergies. Investigating possible associations between students’ science motivation and environmental perspectives, we analyzed data from 429 Irish secondary school students. A significant relationship between positive ‘green’ attitudes (preservation and appreciation of nature) and the motivation to learn science could be identified. Positive environmental preferences showed a linear relationship with a high science motivation, primarily with intrinsic motivation. Supporting the mutualistic relationship between science education and environmental education, students’ weakened motivation to learn science is supposed to be strengthened by environmental topics fostering green attitudes.

Student Agency and Climate Science: Legitimacy, Saliency, and Credibility in Place Based Education
Alexandra T. Gillis, Brooklyn College
Jennifer Adams, University Of Calgary
Brett Branco, Brooklyn College
ABSTRACT

Students are affected by climate-related disasters but lack the salience required to get attention from those in government who can take action. The Resilient Schools Consortium (RiSC) program is an in-school and after-school climate and resiliency program for middle and high school students. The curriculum is by teachers, for teachers designed to educate students on how to be resiliency project managers and climate advocates. The project was modeled with the Cash (2002) framework in mind which says that projects at the science-policy interface are most effective when they are perceived to be salient, legitimate, and credible. RiSC modeled these three qualities by inviting professionals from a wide range of disciplines to participate and mentor the program, creating opportunities for student leadership in the eyes of local policy makers, and providing a platform for city agencies to be inspired by student’s place-based knowledge of resiliency.

Synergizing Science Communities in Project X: Curriculum X for Public Health Citizenship
Katherine R. Bruna, Iowa State University
Lyric Bartholomay, University of Wisconsin, Madison

ABSTRACT
Racial/ethnic minorities are underrepresented in the science field of entomology. Increasing their involvement is crucial at a time when climate change is exacerbating weather events that promote mosquito abundance in ways unique to the human density and structural degradation of urban environments. Insects are a match for youth curiosity about the natural world but use of insects in science classrooms has been hindered by educators’ attitude and training. The Funder X-funded informal science education program, Project X, has a goal of promoting authentic public health inquiry, ambitious science teaching and learning, and an orientation to science pursuits among underrepresented youth and their teachers in an urban community and school setting. Pre- and in-service teachers, alongside youth, apply the tools of science in observing and documenting mosquito phenomena, and in disseminating acquired knowledge of mosquito control and prevention. Their experience is facilitated through a newly developed curriculum, grounded in Ambitious Science Teaching

and Diversity Pedagogy Theory, organized around project-based inquiry oriented to “big questions” about mosquito biology, ecology, and disease transmission. This paper shares quantitative and qualitative data that speak to the impact of this informal science education program on the teacher and youth members of the Curriculum X community.

3/16/20

Concurrent Session 3
8:30 AM-10:00 AM

External Policy And Relations Committee
Admin Symposium-Research Practice Partnerships: Collaborations toward equitable STEM education research, reform, and implementation
8:30 AM-10:00 AM, Mt Hood

Research Practice Partnerships: Collaborations toward equitable STEM education research, reform, and implementation

Stefanie Marshall, University of Minnesota
Deb Morrison, University Of Washington
Philip L. Bell, University Of Washington
André E DeLeón, Nevada Department of Education
Jamie Rumage, Oregon Department of Education

ABSTRACT
Panelists in this session will share their experiences with enhancing researcher-practitioner partnerships (RPPs) concerning Science and STEM education within K-12 schools by examining the ACESSE project model. Composed of members from the Council of School Science Supervisors (CSSS) community and their research partners, panelists will share their learnings within the ACESSE project and other similar collaborations. The session will be moderated by a researcher from the Policy Committee who is involved in past and ongoing ACESSE efforts who will facilitate a conversation around research RPP work. The panelists will discuss the science/STEM needs of states and districts; how they strategically support science/ STEM to be prioritized through a lens of equity; their experiences in a RPPs; and advice for researchers striving to work with schools and at-scale within K-12. We believe this information will support our NARST community as they continue to work with schools, districts, and/or states to enhance science education around the world. Audience interaction will help guide discussion.

Strand 1: Science Learning, Understanding and Conceptual Change
Admin Symposium-Developing Science Literacy and the Potential for Conceptual Change
8:30 AM-10:00 AM, Salmon

Developing Science Literacy and the Potential for Conceptual Change

Keri-Anne Croce, Towson University
Marcia J Watson-Vandiver, Towson University
Huili Hong, Towson University
Renee Rice-Moran, East Tennessee State University

Bridget T Miller, University of South Carolina
Christie Martin, University of South Carolina
Richard Lamb, East Carolina University
Etopio Etopio, University of Buffalo
Jonah B Firestone, Washington State University Tri-Cities
Calvin S Kalman, Concordia University

ABSTRACT
Written texts and verbal communications have the potential to have enormous impact on real world outcomes. While science literacy facilitates opportunities for conceptual change, societies have historically struggled to understand how to use science to guide decision-making. Multiple stakeholders both create communications around science and shape how these communications are interpreted. This panel explores how science literacy is influenced through relationships between educators, students, science journalists, scientists, bioethicists, sociologists, anthropologists, and congress. The results of these discussions may inform decision-making.

Strand 1: Science Learning, Understanding and Conceptual Change
Supporting Understanding with Mathematics and Computational Thinking
8:30 AM-10:00 AM, Columbia
Presider: Kathryn Green, University of Georgia

Effective Algebraic Problem-solving in Physics Through Activation of Prior-Mathematical Knowledge
Süleyman Tursucu, Radboud University Nijmegen
Erik Barendsen, Radboud University & Open University

ABSTRACT
In this qualitative study we examined the question "How can activation of prior mathematical knowledge be used effectively to improve students' symbol sense behavior (SSB) in senior pre-university education when solving algebraic physics problems?". To gain insight into their SSB that is part of algebraic skills, we selected 3 physics students. We designed tasks that triggered their problem-solving abilities and provided insight into their basic algebraic skills (BAS) and SSB. In round 1, students solved these tasks while being videotaped and thinking aloud. Two weeks later in round two, we carried out small interventions by presenting the same problems as shift problems to them. The latter used prior mathematical knowledge by offering hints at the start of these tasks to improve their problem-solving abilities, especially their SSB. We used algebraic skills in a similar way to how these were learned in their mathematics textbooks. We quantified students' SSB by comparing their work to our solution set. We measured the average SSB percentage among all students which increased from 48.5 % in round one to 81.8 % in round two. This implied that the way we implemented activation of prior mathematical knowledge in shift-problems turned out to be very effective.

Intertwining Three Dimensions: Levels of Performance for Computational Thinking While Using Models of Hydrologic Systems
Kristin L. Gunckel, University Of Arizona
Daniel L. Moreno, University of Arizona
Beth A. Covitt, University Of Montana - SpectrUM Discovery Area
Bess Caplan, Cary Institute of Ecosystem Studies
Judith A. Cooper-Wagoner, University of Arizona

John C. Moore, Colorado State University
Alan R. Berkowitz, Cary Institute of Ecosystem Studies

ABSTRACT
Computational thinking is integral to explaining and predicting abstract phenomena, modeling complex systems, and solving challenging problems. In the context of three-dimensional learning, insight is needed into how students engage in computational thinking while interacting with system models. To address this problem, we designed an embedded assessment to elicit students' computational thinking while using models to trace water through hydrologic systems. We collected, from groups of high school students at three sites across the United States, written responses to prompts embedded in a task that incorporated a computational model of either a groundwater or surface water system. We identified three levels of performance on the task. Groups at the lower level could manipulate the model to accomplish the task but viewed the model as isolated from a physical system. At the middle level, groups were able to use the model as a tool and identify parameters relevant to the system. The upper level groups connected hydrologic principles to computational thinking by describing algorithms for tracing water. These findings show that computational thinking develops as students become more proficient at using models and that more sophisticated computational thinking is necessary to use system models to explain and predict phenomena.

Multiple Representations in Computational Thinking: A Study of Second Grade Students
Kristina M. Tank, Iowa State University
Tamara J. Moore, Purdue University

ABSTRACT
With the inclusion of CT as a key scientific practice in the Next Generation Science Standards, we need a better understanding of how students learn to use computational thinking within the context of science. Through research in K-2 classrooms on computational thinking, we noticed that students lack the representational fluency needed to move from one form to another. This led to the following question: How do second grade students use and translate among representations to solve computational thinking tasks? We employed a task-based interview approach with three second grade students who were engaged in four computational thinking tasks set up to engage them in particular representational translations. We found the students often used concrete representations to ease translations, language as a scaffold between translations, and embodied movements as representations or to assist with the translation. Furthermore, the levels of representational maturity showed by the students varied with the difficulty of the task, and spatial orientation was particularly difficult. These results provide important insights into how learners may develop their ability to engage with abstract representations that will be part of future practices associated with activities in science, mathematics, engineering, and computational thinking.

Seeing the Forest through the Trees using Network Analysis: Exploring Student Responses to Physics Problems
Mihwa Park, Texas Tech University

ABSTRACT
In the study, computer simulations and two-tiered questions were incorporated as integral parts of an assessment to investigate students' reasoning in physics questions. The study investigated what scientific ideas students used when they solved physics problems and characterized how those ideas and observed evidence were integrated in students' reasoning. Students' written responses were

subjected to analysis using text analysis techniques. Categories were created to represent ideas, and then Network analysis through NodeXL was conducted to present student reasoning. Findings showed that students' non-normative ideas demonstrated that students were lacking in using energy concept and connecting other scientific ideas to the energy concept. Three ideas, i.e., mass, speed and acceleration, were the most influential factors to their non-normative reasoning. When students presented mixed ideas of co-existence of non-normative and normative ideas, the network analysis result revealed that they connected more ideas that were different and used energy concept more often than just non-normative responses, however; still an object's acceleration due to exerted force had a great influence on their reasoning. In case of normative responses, Network analysis results showed that no longer an object's acceleration, kinetic energy and its speed played important roles in answering the questions.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Modeling and Model-Based Teaching

8:30 AM-10:00 AM, Hawthorne/Belmont/Laurelhurst

Presider: Ryan Coker, Florida State University

Modes and Transfer of Authority: Cultural Historical Activity Theory Analysis of Modeling Activities

Hyun-Jung Cha, Seoul National University
YoonJoo Shin, Seoul National University
Chan-Jong Kim, Seoul National University

ABSTRACT

One of the science practices recommended for science classrooms (NGSS Lead States, 2013), modeling, is a process through which learners can generate explanations and evaluate and revise models through discussions and in so doing develop their understanding of natural phenomena. The key point of modeling as a student-directed practice is in how students develop and exercise authority, especially epistemic authority, when they participate in the scientific practice. Using cultural historical activity theory, we analyzed how the interplay of activity system elements varies within and across modeling activities and how this shapes what students experience as scientific practice. We investigated the modes and shifting of authority wielding and sharing by students and a teacher during modeling activities. Students (age 13-14) and a teacher participated in the modeling-based learning of solar rotation, with the process videotaped and recorded. The results demonstrate that the teacher and students exercised epistemic authority, managerial authority, and positional authority during the modeling activities and that they wield and share different types of authority depending on the modeling stage (i.e., individual modeling, group modeling, whole-class discussion, and model application). Furthermore, we found that authority, particularly epistemic authority, shift from a teacher to students and between students.

Model-Based Science Teaching: Effects on Confidence, Interest, and Attitudes of Female High School Students

Grant Williams, St. Thomas University
John J. Clement, University of Massachusetts
Duy Pham, University of Massachusetts Amherst

ABSTRACT
We investigated the effects of model-based teaching strategies in high school physics, including: having students generate and improve their own explanatory models, using drawings to develop student imagery of visualizable models, and fostering frequent small group and whole class discussions. We found students in a model-based group had significantly larger gains in both comprehension and problem solving confidence levels in comparison to their counterparts in a control group using traditional instruction. This study focuses on a post-course survey used to develop an initial theory of the learning and affective processes within the course that may have played a role in generating these positive outcomes. A factor analysis of the survey results indicated that students overall in the model-based group, and especially females, scored significantly higher on four factors interpreted as: curiosity and interest in science, generating and explaining ideas, using imagery to criticize and revise ideas, and confidence from small group engagement and visual learning. We hypothesize reasons for the experimental group's larger gains in comprehension and problem solving confidence. Based on these initial results, model-based science teaching seems worth investigating further as an instructional innovation that can benefit females and foster their interest in further STEM study and careers.

Using the Preschool Scientific and Engineering Practices (PreSEP) Instrument to Explore Preschoolers' Engagement with Elements of Modeling Practice
Alison R. Miller, Bowdoin College

ABSTRACT
Children are natural scientists and engineers, exploring and manipulating their world through play. While play has long been recognized as critical to children's development, little research has been done to document the ways that children engage in STEM learning through play and specifically how preschoolers construct and use models in their play. The release of the NGSS has renewed focus on fostering STEM learning in preschool and has given researchers and early childhood (EC) educators language to articulate children's engagement with science in play-based learning environments. However, the benchmarks for scientific and engineering practices (Appendix F) of the NGSS begin with the K-2 grade band and prior research around modeling does not capture the varieties and sophistication of models that preschoolers construct during play. Through development and validation of the Preschool Scientific and Engineering Practices (PreSEP) instrument, researchers captured preschooler's engagement with elements of modeling practice at multiple levels of sophistication during more than 100 hours of video-recorded observations across four preschools in the Northeast. Findings from this study suggest that preschoolers engage with multiple elements of modeling practice during periods of free play and that early childhood educators can facilitate this engagement through "stage-setting" of the physical environment and availbale materials.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Analyses of Elementary Preservice and Inservice Teachers' Use of Crosscutting Concepts in Plans and Enactments
8:30 AM-10:00 AM, Meadow Lark/Douglas Fir - 3rd floor
Discussant: Deborah Hanuscin, Western Washington University

Elementary Preservice Teachers' Use of the CCCs in Lesson Plans in Two Practice-Based Science Methods Courses
Carrie-Anne Sherwood, Southern Connecticut State University
Amanda Benedict-Chambers, Missouri State University

Deborah L. Hanuscin, Western Washington University

Investigating Elementary Preservice teachers' implicit use of CCC's overtime through lesson planning
Tina Vo, University of Nevada- Las Vegas
Nicole Thomas, University of Nevada - Las Vegas

Inservice Teachers' Use of Crosscutting Concepts in Planning for 3D Elementary Learning
Anna Maria Arias, Kennesaw State University
Brendan E. Callahan, Kennesaw State University
Michael Dias, Kennesaw State University
Karen Kuhel, Kennesaw State University

Reference to CCCs in Conversation Supporting an Integrated STEM Elementary Unit
Sarah J. Fick, University of Virginia
Jennifer Chiu, University Of Virginia
Kevin W. McElhaney, SRI International

ABSTRACT
The NGSS marks the first time that integration of the crosscutting concepts (CCCs) is an expectation for science learning, requiring teachers to support their students in learning about and using the CCCs. However, the incorporation of the CCCs poses challenges, particularly for elementary teachers who have not previously had experiences as learners with these concepts, and for whom there is already a wide array of instructional demands. This related paper set uses qualitative analysis of teachers' planning for and enactment of NGSS-aligned instruction to consider how elementary preservice and inservice teachers use the CCCs to support student learning. The first paper considers similarities and differences in CCCs use between practice-based science methods courses. The second paper looks across two time points within a science methods course, examining how CCC use changes over time. The third paper investigates the use of CCCs with inservice elementary teachers during a professional development which features 3D learning. The last paper highlights the use of CCCs within the elementary classroom conversations while teaching STEM. The four papers and discussion have implications for teacher educators, curriculum developers, and researchers looking to understand and support the CCCs in science learning.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Secondary Science Teaching in the US: Current Status, Trends over Time, and Factors Affecting Instruction
8:30 AM-10:00 AM, Salon E

Secondary Science Teaching in the US: Current Status, Trends over Time, and Factors Affecting Instruction
Eric R. Banilower, Horizon Research, Inc.
Peggy J. Trygstad, Horizon Research, Inc.
Laura M. Craven,
Patrick S. Smith, Horizon Research, Inc.

ABSTRACT
This symposium reports data from a national survey of K–12 science education in 2018. First, trends using data from a similar 2012 study, conducted just before release of the NGSS, will be presented. On some indicators, the status of secondary science instruction has improved. For example, secondary science teachers are now more likely to have a college degree in science or engineering. Second, we compare novice and veteran science teachers, identifying unique challenges novices face. We also describe common types of induction programs and suggest ways they can be used to help novices. Third, we present results from a path analysis examining the relationship between teacher, class, and school factors and the extent to which teachers emphasize reform-oriented instructional objectives and engage students in the science practices. Overall, the findings shed light on progress towards implementation of the NGSS as well as obstacles and opportunities for more widespread and high-quality implementation.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Affordances for students' literacy and engagement in postsecondary biology
8:30 AM-10:00 AM, Salon D
Presider: Andy Cavagnetto, Washington State University

Case Study Pedagogy and Learning Outcomes: A Framework for Teaching Biology with Narratives
Ally Hunter, University of Massachusetts, Amherst
Melissa Zwick, Stockton University

ABSTRACT
Case study pedagogy is an active learning approach that uses narratives and open-ended questions to deliver science content. However, more information on how students learn with case studies in undergraduate classrooms is needed. Understanding the variables that impact learning with case studies and any relationships between those variables is necessary to elucidate how students learn with case studies. The purpose of this study was to investigate the use of a case study about a mule giving birth on meiosis learning outcomes in an undergraduate biology classroom. This study was guided by, and builds on, a conceptual framework for case study pedagogy that considers the role of prior content knowledge and situational interest in learning with case studies. This study extends the framework to include an additional measure of learning: cell division content knowledge. Our findings support the framework in that students demonstrated transfer of knowledge, maintained situational interest during the case study and attributed their learning of biology content to the case study pedagogical approach. Further, we found that students possessed cell division content knowledge after the case study and were able to transfer knowledge to a new context, independent of their prior meiosis conceptual knowledge.

Developing Learning Progression for Botanical Literacy and Measuring Learning Gains: Construct Modeling Approach
Pongprapan Pongsophon, Kasetsart University, Bangkok, Thailand
Artitaya Jituafua, Suratthani Rajabhat University, Suratthani, Thailand

ABSTRACT
This study aims to develop a learning progression for botanical literacy and measure learning gains in Thai pre-service science teachers. The participants (n=49) participated in a 15-week, inquiry and community- based gardening education course. They were measured their botanical literacy before and after the instruction by a 50-item multiple choice test. A hypothetical model of the construct was

proposed and validated using construct modeling approach. Dichotomous Rasch model was employed. The results indicate the model fit data well. We found that the hypothetical model was confirmed. Botanical literacy was a linear construct and comprised conceptual and procedural domains. Each domain had several core ideas presented in order of increasing difficulty, consistent with the pre-determined conceptual complexity - the conceptual domain, for example, core ideas placed on a construct map from easy to difficult are plant diversity, plant morphology, and plant ecophysiology. To measure learning gain, we fixed pre- and post- item difficulty, estimated post-instruction person ability and compared the means of pre- and post-instruction person ability using Welch t-test. We found the gain was statistically significant ($p < 0.01$). This study discusses theoretical, pedagogical and methodological implication in biology education.

Exploring Approaches to Engaging Undergraduates in Research: Differential Impacts on Students' Self-efficacy and Science Skills

Kelly M. Schmid, Syracuse University
Jason R. Wiles, Syracuse University

ABSTRACT

Several approaches toward engaging undergraduates in scientific research are common at colleges and universities, including undergraduate research experiences (UREs) based in faculty research laboratories, course-based undergraduate research experiences (CUREs) of varying levels and types, and courses rooted in primary research literature that may be precursors to student research experiences. We examined the outcomes for students enrolled in UREs (N=12), CUREs (N=32), and a literature-based introduction to science research course (N=12) in a biology department at a large, private, research intensive university in the northeastern United States. Students enrolled in UREs and an authentic CURE with student-driven research had significant increases in science skills, but not in science self-efficacy. Students enrolled in the introductory research literature course had significant increases in all measured factors related to science self-efficacy. Students enrolled in a CURE that did not involve independent, student-driven research projects showed no significant overall improvement in either science skills or self-efficacy. We therefore recommend an introduction to science research through primary literature course as a way to build self-efficacy prior to CUREs and UREs, and possibly as a way to better match undergraduates with potential research mentors for future research engagement.

Exploring Peer Learning Assistants' Impact on Student Performance and Perceptions in an Undergraduate Biology Course

Brittney A Ferrari, University of Georgia
Jonathan Dees, University of Georgia
Norris Armstrong, University Of Georgia
Kristen Miller, University of Georgia
Julie M. Kittleson, University Of Georgia

ABSTRACT

This study investigated the effect of Peer Learning Assistants (PLAs) on student learning in an undergraduate Biology course. A group of seven PLAs alternated attending two sections of the same course and their impact on student performance was examined by comparing student responses to clicker and exam questions when PLAs were present versus absent in the class. Students responded more accurately to clicker questions when PLAs were present but this trend did not extend to exam questions that corresponded to the clicker questions. However, students did perform better on exam questions that were related to major class activities when PLAs were present in the class, indicating

student learning may be affected by direct feedback from PLAs. Additionally, a Likert-scale survey was used to examine how students in the course perceived the impact of PLAs on their learning. Survey questions asked about student interactions with PLAs as well as students' trust and value of PLAs. Trust and value of PLAs was high and responses indicated that PLA used several inquiry-based strategies to support student learning, particularly by providing explanations and asking guiding questions. The results from this study demonstrate that PLAs can impact student learning through direct feedback and inquiry-based approaches.

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

Investigating faculty change

8:30 AM-10:00 AM, Salon C

Presider: Jana L. Bouwma-Gearhart, Oregon State University

A Close Look at Change: Understanding Factors that Shape Instructor Evolution during Instructional Reform Efforts

Katelyn Southard, University of Arizona
Jonathan Cox, University of Arizona
Young Ae Kim, University of Arizona
Jazmin Jurkiewicz, University of Arizona
Lisa Elfring, University of Arizona
Paul Blowers, University of Arizona
Vicente A. Talanquer, University of Arizona

ABSTRACT

As college instructors begin using tools like instructional tasks in the classroom, it is important to understand what it takes to facilitate and sustain long-term adoption of constructivist perspectives and evidence-based teaching strategies to guide student learning. In order to aid college instructors in the transition from traditional lecture-only approaches toward adopting high-level instructional tasks, we must better understand the individual and contextual strengths and challenges that impact an instructor's reform efforts. This study presents a close description of change, through microgenetic case study analysis, as one instructor engages in instructional reform efforts. We aim to characterize elements of change, focusing on factors that facilitated change and assisted in navigating barriers during a period of significant instructional reform. Findings indicate: 1) the value of an augmented view of classroom "support" within an instructional team, 2) the importance of finding balance in instructional task design, 3) the power of rich lines of team communications in stimulating the need for aligned learning objectives, and 4) personal attributes linked to instructor change. Understanding factors that influence change during the process of instructional reform provides insights that can inform professional development and support for instructors navigating this complex and challenging transition.

Are Faculty Changing? Sampling Effects on Measures of Instructor Adoption of Evidence-based Teaching Practices

Justin A. Goodridge, Stony Brook University
Lucy H. Gordon, Stony Brook Univeristy
Ross H. Nehm, Stony Brook University - SUNY
Gena C. Sbeglia, Stony Brook University

ABSTRACT
Many positive educational outcomes are associated with student-centered learning, justifying calls for its widespread adoption in undergraduate education. Recent work has focused on measuring progress in faculty adoption of student-centered instruction at the national level. The COPUS (Classroom Observation Protocol for Undergraduate STEM) has figured prominently in this work. Little work has explored how the number of classes observed using the COPUS impact claims about faculty teaching behaviors. Our study explores two research questions: (1) How does the number of classes sampled using the COPUS impact the measurement of course-level learning environments? And (2) How does the number of classes sampled impact the measurement of changes in an instructor's behavior over time (multiple years)? Trained COPUS raters scored 26 behaviors in 146 classes taught by three faculty over 4 years. We simulated varying sampling intensities (i.e. number of classes observed) by randomly selecting classes (using 1000 trials) and calculating the proportion of each instructional strategy correctly classified. Our findings show that the number of observations used in prior studies are often inadequate and raise concerns about the accuracy of published work measuring faculty adoption of reform-based practices.

Re-thinking notions of change and learning as ontological work in college instructors' professional development

Sophia (Sun Kyung) Jeong, University of Georgia
Paula Lemons, University of Georgia

ABSTRACT
This proposal is a theoretical paper that calls into question the predominant notions of change and learning in the context of college instructors' professional development (PD). We deconstruct the foundational notions of change and learning as we know them today in the broader context of K-16 science education. The purpose of this paper to re-conceptualize these constructs as effects of ontological work. We problematize the current paradigm within which PD programs operate, which conceptualizes change or change strategies from an implementation standpoint to impact instructors' practices. We also call into question the specific perspective in science education research that predominantly localizes learning within individual cognition. Drawing on theories of new materialism, we re-conceptualize the notion of learning as material-discursive events that assemble students, the instructor, and physical objects in the classroom, and therefore, change is always and already occurring. In doing so we hope to catalyze a paradigm shift to re-consider the ways in which science education as a field thinks about change and learning in implementation PD studies and how we do PD research.

Strand 6: Science Learning in Informal Contexts

Family engagement in informal science experiences

8:30 AM-10:00 AM, Salon F

Presider: Scott A. Pattison, TERC

"I have a gut feeling about this" adult engagement with SSI in daily life

Keren E. Dalyot, Technion Israel Institute of Technology
Ayelet Baram-Tsabari, Technion - Israel Institute of Technology

ABSTRACT
This exploratory study aims to better understand how adults engage with science in the context of real-life socio-scientific issues (SSIs). Specifically, we examined how parents engage with the issue of radiation from Wi-Fi routers in schools, an issue encountered by parents across the world. Radiation from wireless internet connection (Wi-Fi) routers is a type of radio frequency electromagnetic radiation. Nowadays, exposure to RF radiation is widespread; from Wi-Fi routers in workplaces, homes, restaurants, and even buses and trains to cell phones and microwave ovens. The proliferation of devices emitting RF radiation has entailed some public concern and media publications that we are underestimating the health risks associated with RF radiation and ignoring some studies that have demonstrated risk, even if the scientific consensus is different. This study takes a qualitative approach using semi-structured interviews with 35 parents of primary school aged children. Our findings illustrate nonscientists engagement with a relevant SSI where personal perceptions, and social networks play a much bigger role than scientific knowledge. Even though most interviewees talked about using the internet and google for learning more about SSIs, they attested that in the end they mainly rely on their personal perception of the issues under discussion.

Building the Cultural Wealth of Parents to Support Science Career Aspirations of Youth

Megan Ennes, University of Florida
M. Gail Jones, North Carolina State University
Emily M. Cayton, Campbell University
Katherine Chesnutt, North Carolina State University
Pamela Huff, North Carolina State University

ABSTRACT
Emerging research suggests that families are key to developing the science interests and career aspirations of youth. In order to increase the diversity and numbers of individuals choosing to pursue STEM careers, it is important to better understand the factors that influence career aspirations. The influence parents have on their children's career aspirations comes from many factors including their science capital and family science habitus. This study examined the influence of a museum-based family STEM program geared to increase the STEM career aspirations of elementary youth on the parent participants (N = 44). The parent participants completed a pre and post program survey and 11 of the parents participated in intense case studies. Examining the survey and interview results using Community Cultural Wealth Theory found that as parents engaged with their children in STEM investigations during the program, their cultural capital, including science, social, familial, navigational, aspirational, and linguistic capital, and their family science habitus increased. This suggests that a family STEM program may be an effective strategy for building the science career aspirations of youth by supporting and increasing the capital of the parent participants.

Family Matters: A Mixed-Methods Study of Everyday Science Talk and STEM Identity Development

Remy Dou, Florida International University
Heidi Cian, Florida International University

ABSTRACT
Hispanic youths have traditionally been marginalized from participation in STEM careers, though efforts have been made to increase diversity in STEM careers through targeted learning interventions for these students. However, these efforts often do not purposefully address STEM identity formation, which is a construct closely related to career choice in STEM. Building on previous work that highlights the value of "science talk", we focus on the childhood experiences of Hispanic/Latine college students that have

informed the construction of their STEM identity and contributed to their decisions to enroll in STEM programs. We use a mixed methods approach to explore the relationships between experiencing talking with others about science and their sense of recognition and identity in STEM. Our quantitative results suggest that talking about science with close family members is associated with students' sense of recognition as STEM people but talk with extended family and friends is not significant. Our qualitative results further demonstrate the value of impromptu science talk moments as springboards for supporting STEM recognition and identity, particularly considering the inhibitory role that formal school settings played. These outcomes suggest that facilitating talk moments between children and parents may offer valuable contributions to children's STEM identity development.

Using Question Prompts to Support Families' Embodied Sensemaking and Reasoning in a Water Quality Workshop
Lucy R. McClain, Pennsylvania State University
Yu-Chen Chiu, Pennsylvania State University
Heather Toomey Zimmerman, Pennsylvania State University

ABSTRACT
This study addresses the increasing interest in family learning in informal settings by investigating strategies to better engage families in science talk and practices. As part of a larger design-based research study, we examine how scientists and parents use think-pair-share discussion prompts to support families' understandings about local community water sources and facilitate experimentation with a surface and underground water model. Grounded in sociocultural theory of learning, we focus on parent-child interactions and family sensemaking. We analyzed four water quality workshops with 44 hours of video data from 13 families. We examined how the structure of the family question prompts supported or hindered families' learning. Through our analysis, we identified three emerging patterns of how the prompts delivered by STEM professionals influenced parent-child conversations and interactions on science content. Our findings suggest that prompts designed to connect science to family experiences can support family sensemaking practices. Also, prediction prompts and other resources (such as learners' workbooks, pointing and gestures, and a water model) were found to support families' sensemaking about water sources and water quality.

Strand 7: Pre-service Science Teacher Education
Context-Dependent Approaches to Partnering with Mentor Teachers: Supporting Novice Teachers Ambitious Science Teaching
8:30 AM-10:00 AM, Salon A
Discussant: Matthew Kloser, University Of Notre Dame
Presider: Todd Campbell, University of Connecticut

Context-Dependent Approaches to Partnering with Mentor Teachers: Supporting Novice Teachers Ambitious Science Teaching
Todd Campbell, University of Connecticut
Jessica J. Thompson, University Of Washington
David Stroupe, Michigan State University
Mark Windschitl, University Of Washington
Scott McDonald, Pennsylvania State University
April Lynn Luehmann, University Of Rochester
Lisa Lundgren, University of Connecticut

Brian Hancock, Alma College
Sara Hagenah, Boise State University
Matthew Kloser, University Of Notre Dame

ABSTRACT
In the field of science teacher education, a growing number of university science educators have begun to collaborate around the Ambitious Science Teaching (AST) sets of high-leverage core practices as a framework and mechanism for supporting novice teachers in engaging students in K-12 schools in the innovative forms of participation envisioned in the Framework and the NGSS. However, as we, university science educators, sought to support novice teachers in taking up the AST core practices, the important role mentor teachers played quickly became apparent, especially as we began to make connections between the extent to which novice teachers' enactment of core practices thrived or was diminished in relation to, among other things, the extent we had previous opportunities to collaborate and negotiate common commitments to teaching and learning with mentor teachers. Given our recognition of the benefits of close collaborations with mentor teachers, as well as our recognition of the varied context in which science teacher education unfolds in various teacher preparation programs nationally, this session is designed as a forum for illuminating the necessarily varied context-specific approaches and foci that the presenters have undertaken to engage in both their collaborative work and research with mentor teachers.

Strand 7: Pre-service Science Teacher Education
Retaining Preservice Physics Teachers
8:30 AM-10:00 AM, Salon B
Presider: Angela Fitzgerald, University of Southern Queensland

What matters? Influence of Quality and Quantity of Learning Opportunities in Pre-Service Physics Teacher Education
Dustin Schiering, Leibniz Institute for Science and Mathematics Education (IPN Kiel)
Stefan Sorge, Leibniz Institute for Science and Mathematics Education (IPN Kiel)
Knut Neumann, Leibniz Institute for Science and Mathematics Education (IPN Kiel)

ABSTRACT
The present study investigates the influence of the quantity and quality of learning opportunities on pre-service physics teachers' content knowledge (CK) and pedagogical content knowledge (PCK) development. Due to the fact that CK and PCK have a significant impact on students' learning outcomes, there is a great demand in creating effective learning opportunities during teacher training programs. Whereas the quantity of learning opportunities has been demonstrated to have a substantial impact on pre-service teachers' CK and PCK development, results on the quality of learning opportunities for pre-service teachers are missing. To address this issue, data from a longitudinal study with N = 107 pre-service physics teachers were analyzed. Principal components analyses and structural equation modelling were utilized to examine the impact of quantity and quality of learning opportunities on pre-service teachers' CK and PCK development. Findings show that there are different quality dimensions of pre-service teachers' learning opportunities. Additionally, quantity and quality of CK learning opportunities are related to the CK development. Contrary to our assumption, quantity and quality of PCK learning opportunities indicated no impact on the gain in PCK. However, pre-service teachers' PCK is influenced by CK and thus seems to benefit from CK learning opportunities.

Engaging in the Science Practices: Preservice Elementary Teachers' Experiences and Lesson-Planning in a Physics Course

Adam Bennion, University of Michigan
Elizabeth A. Davis, University of Michigan

ABSTRACT

The NGSS represents a departure from the sometimes rigid view of science found in the "scientific method", and offers teachers a more authentic way to engage students in their science classrooms. We studied the opportunities preservice elementary teachers had to engage in the science practices during a physics content course, how they planned to use the science practices in their own teaching, and the alignment between the them. We collected data in the form of lab sheets, student lesson plans, and semi-structured interviews. We focused on five preservice teachers who were selected based on coursework and interview responses. All of the preservice teachers engaged in the science practices and incorporated them into their lesson plans with different degrees of success. Our results indicate that the focal participants' engagement in and use of the practices in their lesson plans (e.g. Planning & Conducting Investigations) was influenced in certain ways by the substance of the course. Our findings can help teacher educators better understand what preservice teachers know about the science practices, how having opportunities to engage in the practices might shape their planning, as well as the influence content courses can have on future pedagogy.

Creating Coherent Connections to Support STEM: Utilizing Design in a Teacher Education Program

Ibrahim Delen, Usak University
Consuelo J. Morales, Michigan State University CREATE for STEM Institute
Joseph S. Krajcik, Michigan State University

ABSTRACT

Integrating STEM (science, technology, engineering, mathematics) into science education, at all levels, has been of global interest for many years. Yet, the science education research community has struggled to find concrete solutions for integrating various STEM disciplines in a coherent manner. This challenge raises the following question: What is needed to create coherent and integrated connections to support STEM, utilizing design in a teacher education program? We conducted a study with two cohorts of science pre-service teachers (PSTs) in which college level courses (physics, laboratory and methods) were purposefully connected to explore a variety of design challenges to create design products. Through these integrated course exposures, PSTs delved deeply into the science content as they also worked to create coherent learning environments for integrating STEM components through design. Results indicate that PSTs need to be exposed to multiple design experiences, over time, in order to demonstrate a greater ability and more confidence in creating coherent and integrated STEM environments around design. This work has the potential to be a valuable framework that supports teachers and teacher educators to integrate STEM in a coherent manner.

Choosing to Teach Physics: Faculty and Student Perspectives

Lauren Madden, The College of New Jersey
Susan C. Eriksson, Virginia Tech
Nathan Magee, The College Of New Jersey, Physics Department
AJ Richards, The College of New Jersey
Marissa E. Bellino, The College of New Jersey
Desaree Vaughan, The College of New Jersey

ABSTRACT
Our study seeks to better understand the reasons why individuals choose to pursue careers in physics teaching. There is a high need for well qualified teachers across all STEM content areas, and this need is especially pronounced when it comes to secondary physics. The study takes place at a primarily undergraduate institution in the northeastern United States. The study uses a modified version of Watt and Richardson's (2007) Factors Influencing Teacher Choice (FIT-Choice) model as an analytical frame to describe why individuals choose to teach physics. The study uses a mixed methods concurrent triangulation approach (Creswell & Plano-Clark, 2017). Qualitative data sources include transcribed interviews (with both physics/secondary education majors and physics faculty), providing multiple perspectives on students' choice to pursue teaching. Quantitative data sources used include a survey based on Watt and Richardson's FIT-Choice instrument administered to all physics undergraduates at our institution (those enrolled in a physics/secondary education dual major and not). Our findings revealed several clear trends including: prior teaching and learning experiences were critical in helping an individual choose to become a teacher; future teachers reported a clear love for the subject (physics); specific skills and expertise are needed to effectively teach secondary physics; and physics teaching is a mechanism for enhancing social equity. There was some discussion of social disuasian from a teaching career and considering teaching as a "fallback career," but this was relatively small compared to other trends. Implications for this work could include creating tools to aid in recruiting a larger pool of highly qualified secondary physics teachers.

Strand 8: In-service Science Teacher Education

Context in Professional Development

8:30 AM-10:00 AM, Pearl
Presider: Casandra Gonzalez, Boston College

Bring your own context: Personalization of high-school science teachers' professional development

Ron Blonder, The Weizmann Institute Of Science
Bat-Shahar Dorfman, Weizmann Institute of Science
Bronwyn Terrill, Garvan Institute of Medical Research
Kate Patterson, Garvan Institute of Medical Research
Anat Yarden, Weizmann Institute Of Science

ABSTRACT
In this paper, we present a design model of a professional development workshop for high-school science teachers. The model enables the participants to bring their own educational context and expertise into the workshop. To evaluate the model, it was implemented in a workshop that dealt with the use of animated and video content in biochemistry. The effect of the workshop on the participants' knowledge and confidence was measured. In planning the workshop, we dedicated formal slots in the schedule to the teaching context and the teachers' professional knowledge – thus making the workshop relevant for teachers in different contexts. Similar workshops were run with chemistry and biology teachers in Israel and Australia, and the effect on the various teachers was compared. It was found that although the teachers came from different fields (chemistry and biology), and from two different countries, the outcomes were quite similar. Namely, the workshop proved similarly effective for all the participating teachers. The participants succeeded in applying the PD content in planning a chemistry/biology class and editing a personalized video that they believe addressed the specific needs of their students. We therefore suggest that the model developed for the teachers' PD is effective.

Examining Elementary Teachers' Pedagogical Perspectives and Agency to Teach Science Through School-Based Science Professional Development

Jessica Lee Chen, Teachers College, Columbia University

ABSTRACT

This multiple case study focuses on three fourth-grade teachers' pedagogical perspectives and the ways they engaged their agency to teach science as they participated in a yearlong school-based science professional development program in an urban, high-stakes testing school environment. Drawing on sociocultural frameworks, the structure-agency dialectic was used to examine the school structures that constrained and marginalized science, and the teachers' agency to transform these structures into more enabling ones for equitable and empowering science learning opportunities. Sources of data included teacher interviews, field notes, and reflective teacher questionnaires. The data was coded for emergent themes. Findings showed that teachers' pedagogical perspectives towards teaching strongly influenced how they understood and taught science, and how they engaged their agency to transform or reproduce structures that constrained science in their classrooms. Differences in years of teaching in a high-stakes testing environment also influenced their pedagogical perspectives and agency to teach science. This study emphasizes the importance of considering individual teachers' experiences, knowledge, orientations, and pedagogical perspectives, which contribute to their sense making of and participation in justice-oriented science professional development.

The Complexity of Responsiveness: How Professional Development Providers Shape their work with Elementary Science Teachers

Patricia S. Bills, Oakland University
Madhura Kulkarni, Center for Intergrative Natural Science & Mathematics, Northern Kentucky Univ.

ABSTRACT

This paper is an account of two teacher educators' (TEs) work with and responsiveness to practicing elementary science teachers over 3 years in a university-based STEM center professional development program. Drawing upon components of complexity thinking and situated learning theory, we developed descriptions of the ways that TEs respond to the needs of the local teachers with whom they work over time as they work across multiple interdependent contexts. We named the compilation of these contexts and their interdependence a "contextual through line." We used a case study design along with participant observation strategies to develop our understanding of and description of TEs' practice in light of the contextual through line. In our program, TEs deliver PD sessions in live teaching demonstrations in elementary classrooms in real time during the regular school year. We found: 1) for multiple reasons, our TEs' work is uniquely positioned to be responsive to participants' intellectual and material needs (as well as others) over time, 2) the public nature of the live teaching demonstrations positions TEs' as credible experts to both teachers and their students, 3) TEs have specialized knowledge of each intertwining context that shapes and is shaped by their practice.

What Kind of Active Learning? Examining Intersections of Learner Positioning and Engagement in Professional Development

Patrick J. Enderle, Georgia State University
Jennifer Schellinger, FSU
Claudia Hagan, Georgia State University
Ozlem Akcil Okan, Florida State University
Ellen M. Granger, Florida State University

Todd Bevis, Florida State University

ABSTRACT
This study examines the nature of teachers' engagement in different types of learning activities offered during two successive iterations of a summer professional development experience. Professional development literature emphasizes the need for teachers to be engaged in "active learning" to heighten the effectiveness of the experience for supporting changes in their thinking and practice; however, this "active" nature can vary greatly, and thus, we were interested in examining how teachers respond to different variations. Using positioning theory, we analyzed two types of learning episodes positioning teachers as either content-learners or pedagogical-learners. We compared observations of teachers' engagement with their peers between the two types of activities. Teachers' reflections and exit survey responses were also examined to determine patterns in what learning experience they valued and the reasoning behind those responses. From these analyses, a prominent trend emerged demonstrating teachers were more actively engaged and found more value in activities where they were positioned as a content-learner, where they worked to build scientific understandings in similar ways as their students. Further development of engagement profiles for different teachers also provide more nuance to the nature of their engagement. These profiles are further described in the presentation.

Strand 11: Cultural, Social, and Gender Issues

Critical Views of Science Education Research in Linguistically and Culturally Diverse Contexts

8:30 AM-10:00 AM, Salon I

Discussant: Maria Varelas, University Of Illinois At Chicago

Presider: Sara E. Wilmes, University of Luxembourg

Critical Views of Science Education Research in Linguistically and Culturally Diverse Contexts

Helen Douglass, University of Tulsa
Semiha Gun-Yildiz, University Of Massachusetts Dartmouth
Minjung Ryu, Purdue University
Sara Salloum, University of Balamand
Christina Siry, University Of Luxembourg
Mavreen Rose S. Tuvilla, Purdue University
Geeta Veerma, University of Colorado Denver
Sara E. Wilmes, University of Luxembourg
Casey E Wright, Purdue University
Maria Varelas, University Of Illinois At Chicago

ABSTRACT
Grounded in a critical examination of science education in culturally and linguistically diverse contexts, this symposium brings together a group of international scholars with the goal of engaging in critical discussion about our research with the aim of moving toward more equitable research, and ultimately more equitable science instructional practices. Panel presentations from our five diverse research projects conducted in primary, secondary, and out-of-school contexts will first be shared and will serve as the starting point for discussing critical questions regarding the theoretical and methodological approaches we employ. Following from these short panel presentations, attendees will join with panelists in small-group conversations centered on topics such as methodologies, theoretical lenses, intersections between research and practice, as a means to create spaces to discuss, to interrogate, and

to share resources relative to our research investigating science education in culturally and linguistically diverse settings.

Strand 11: Cultural, Social, and Gender Issues
Exploring Science Identities through the lenses of Possible Selves
8:30 AM-10:00 AM, Salon H

"Now I Actually Enjoy Teaching Science!" Exploring the Emerging Science Identity of a Veteran Elementary Teacher
Terrance Burgess, Syracuse University

What makes science careers possible for undergraduate science majors? Understanding the roles of science capital and science outreach
Allison J. Gonsalves, McGill University
Hailey Iacono, McGill University
Alexandre Soares Cavalcante , McGill University
Emily Sprowls, McGill University

Enacting identities, imagining worlds: How visions of possible selves shape science teacher planning and persistence
Stacy Olitsky, Saint Joseph's University

Negotiating, resisting and aligning narratives about the future. An ethnographic study of higher education science students' possible selves
Katia Kromann, University Of Copenhagen
Henriette T. Holmegaard, University Of Copenhagen

ABSTRACT
This paper set investigate the identity-negotiations of science students and teachers through the perspective of future possible selves. In paper 1, the author considers a veteran science teacher's identity and how their possible future self shifted from non-science to science. In paper 2, the possible future selves of undergraduate science majors are examined. In paper 3, teachers' negotiation of multiple future selves is presented, along with a consideration of the structural challenges limiting recognition of some future selves. Paper 4 presents an ethnography of higher education students' future science identities. Finally, we consider the following questions for discussion: What makes a future self really "possible"? How are future selves in science / science teaching related to current, past, and parallel selves? How do possible future selves influence students' and teachers' actions in science? What contextual and cultural influences are mediating future selves in science? How can we broaden the range of future selves in science that are possible?

Strand 11: Cultural, Social, and Gender Issues

Persistence & Retention Strategies for Underrepresented Populations in STEM

8:30 AM-10:00 AM, Salon G

Presider: Gillian U. Bayne, Lehman College Of CUNY

New Majority Students' Challenges in STEM Education and their Coping Strategies to Thrive

Mojtaba Khajeloo, University Of Missouri–Columbia
Joinee Taylor, University Of Missouri–Columbia
Terrell R. Morton, University Of Missouri–Columbia
Marcelle Siegel, University Of Missouri–Columbia
Johannes Schul, University Of Missouri–Columbia
Charles Nilon, University Of Missouri–Columbia

ABSTRACT

Scholars suggest that there are barriers and challenges that shape the perceptions and experiences of many New Majority (NM) students – students of color, first generation college students, adults, transfer students, and students from low income families – within STEM fields. In this study, we examined the lived experiences of four NM students enrolled in postsecondary STEM programs. Using the Phenomenological Variant Ecological Systems Theory (PVEST) framework, we specifically analyzed the challenges NM students encountered within STEM education, the support systems that existed for these students, and the manner in which NM students navigated their STEM learning environments to thrive in their major. We found exclusion and under-preparedness as two of the main challenges our participants encountered in their learning environments and that a mixture of social and academic supports associated with their identity helped them to cope with the challenges. We report our findings on the connection between new majority identities, experienced stress, and adaptive coping responses.

The Effect of Peer Mentoring and Achievement Goals on Persistence for Female Undergraduate STEM Majors

Jennifer Gatz, Stony Brook University
Angela M. Kelly, Stony Brook University
Monica Bugallo, Stony Brook University

ABSTRACT

This presentation examines the effectiveness of an undergraduate science, technology, engineering, and mathematics (STEM) mentoring program for women at a research university in the Northeast U.S. Although a large body of literature supports achievement goal theory in predicting achievement-related behaviors, the relationship between achievement goals and achievement-related outcomes, particularly for women in STEM, is not clear. A convergent parallel mixed methods design was employed to examine relationships among the social structures of the program, students' competency beliefs, and achievement goals of first-year students (n=46). Survey Likert questions and open-ended responses indicated students experienced a high level of social integration and mastery-oriented academic goals. Students reported moderate levels of performance-oriented goals, indicating a lesser focus on how they valued the opinions of others in assessing their own strengths. Mastery-oriented goals had moderate correlations with feelings of career-related competency. Social support and academic advising were the two most valued aspects of the mentoring program. Preliminary findings indicate that social constructs, competency beliefs, and mastery-oriented achievement goals may be positive predictors of persistence

in STEM for first-year female students. University faculty may replicate such programs to foster social networks and a sense of belonging for undergraduate women in STEM.

The Role of Resilience in the STEM Identities of Post-Secondary Students: A Qualitative Metasynthesis
Karen Benn Marshall, Oakwood University
Sylvia M. James, National Science Foundation

ABSTRACT
The purpose of this qualitative metasynthesis is to explore the relationship between science, technology, engineering, and mathematics (STEM) identity and resilience in racially and ethnically diverse post-secondary students. This study identifies experiences that impact STEM identity development in diverse undergraduate and graduate students. The results of a constant targeted comparison (an analytical technique not often used in educational studies) between STEM identity and student resilience suggests that STEM identity contributes to resilience in diverse students. Findings suggest that common adverse experiences that may impact racially and ethnically diverse students can be overcome in the presence of a well-developed STEM identity. This resilience in STEM appears to be impacted by factors such as group membership, race, gender, agency, internal and external supports, validation, and access. Diverse students may employ a range of coping mechanisms including family and peer support systems, as well as a personal cache of innovative approaches to self-define their STEM identities and help them navigate the academic milieu. Additional research is needed to better understand the relationship between a strong STEM identity and resilience in diverse undergraduate and graduate students.

Two-year STEM Pathways and Transitions across Minority Serving Destinations
Felisha Herrera, San Diego State University
Victoria Rodriguez-Operana, San Diego State University
Marlena Wolfgramm, Claremont Graduate University/San Diego State University

ABSTRACT
The shortage of students trained in science, technology, mathematics, and engineering (STEM) calls for an improved understanding of the critical role of the multiple student pathways across various institution types and sectors of postsecondary education, particularly for underrepresented students. Community colleges (CCs) and Minority Serving Institutions (MSIs), including Hispanic Serving Institutions (HSIs), provide several pathways and linkages to the STEM pipeline and are key access points to postsecondary education for historically underrepresented racial minorities. This study examines STEM pathways for URM students who began at CC, with an emphasis on student mobility and institutional contexts (HSIs/emerging HSIs) and reveals important implications for education policy and practice and advancement of future research.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Nature of Scientific Practicies
8:30 AM-10:00 AM, Portland
Presider: Sibel Erduran, University of Oxford

Establishing a Framework for the Culture of Scientific Research and Application to Course-based Undergraduate Research
Jessica Dewey, University of Minnesota
Anita Schuchardt, University of Minnesota

ABSTRACT
When students first take undergraduate laboratory courses, they are asked to border cross into the culture of scientific research. Certain cultural aspects of scientific research may act as barriers or entry points to this border crossing. While much work has been done to describe the culture of science there is no consistent agreement on which aspects may be important to the scientific research culture. This study aimed to (1) establish a framework for the Culture of Scientific Research (CSR) through a literature review guided by a specific definition of culture and (2) apply this framework to the experiences of undergraduate students after participating in a Course-based Undergraduate Research Experience (CURE). Our literature review resulted in a CSR Framework comprised of three broad categories: practices, norms/expectations, and values/beliefs. We identified 25 specific aspects that were previously established in the literature or were supported by discussions with practicing scientists. While student responses addressed 20 of the 25 aspects in our framework, they focused mostly on the norms/expectations and practices with very few mentions of the values/beliefs. This is a first step towards a deeper understanding of how students interact with the cultural aspects of scientific research when border crossing.

Nature of Science and The Nature of The Scientist - Socialization in Scientific Communities
Ashwin Krishnan Mohan, Pennsylvania State University
Gregory J. Kelly, Pennsylvania State University

ABSTRACT
The Family Resemblances Approach (FRA) to Nature of Science (Irzik & Nola, 2011; Erduran & Dagher, 2014) brings together diverse aspects of the nature of science, viewing science as a cognitive-epistemic and social-institutional system. The FRA, along with other models of NOS in the literature, has been framed from the perspective of the entire scientific enterprise and community. In this paper we adopt the FRA for its interpretational flexibility but switch the analytical focus to the individual, and question how scientists conceptualize their own natures of science as they are socialized into specific epistemic cultures (Knorr-Cetina, 2009). Terming this the Nature of the Scientist (NOSist), we consider how the NOSist interacts with NOS to enable or constraint participation and socialization within the scientific research community. We also consider the case of graduate students, who are newcomers into this community of practice (Wenger & Lave, 2001; Feldman, Divoll, & Rogan-Klyve, 2013) and consider the implications this has for the structure and design of graduate programs in the sciences. We argue that the scholarship in the nature of science needs to be complemented by a switch in perspective by considering how the nature of individual scientists affords their continued participation in scientific communities.

The Nature of Scientific Explanation(NOSE):A Philosophically-Guided Framework Examining the Nature and Quality of Scientific Explanations
Sahar Alameh, University Of Illinois At Urbana–Champaign
Fouad Abd-El-Khalick, University Of North Carolina At Chapel Hill
David E. Brown, University of Illinois

ABSTRACT
Issues regarding scientific explanations have been of interest to philosophers from Pre-Socratic times. The notion of scientific explanation is of interest not only to philosophers, but also to science educators. In the Next Generation Science Standards (NGSS), scientific explanation is presented as a goal for science, a tool for learning about science, and a process of answering a scientific question. However, the NGSS do not offer detailed conceptualization of the nature of explanation. Furthermore, there is a dearth of research on conceptualizing explanation in science education. Scientific explanation seems to be ill-defined (or left undefined) among researchers, science teachers and students. Guided by philosophical models, this study proposes a framework– The Nature of Scientific Explanation (NOSE) – for assessing the nature and quality of explanations. The development of NOSE is an effort to fill the existing gap by constructing a framework specific to scientific explanations that is grounded in philosophical models of scientific explanation. NOSE is among the first attempts in science education that aims to develop a functional framework of scientific explanation that is useful for K-12 science teaching and learning. Synthesizing the applicability of philosophical models into science education is important for science educators to explore students' scientific explanations.

Strand 14: Environmental Education
Place-based and community-based education
8:30 AM-10:00 AM, Eugene
Presider: Scott Byrd, Maine Mathematics and Science Alliance

Added value of contextualizing learning about living organisms in schools' immediate surroundings
Jean-Philippe Ayotte-Beaudet, Université de Sherbrooke
Pierre Chastenay, Université du Québec à Montréal
Alain Paquette, Université du Québec à Montréal
Michael Giamellaro, Oregon State University - Cascades
Fatima Bousadra, Université de Sherbrooke
Marie-Claude Beaudry, Université de Sherbrooke
Kassandra L'Heureux, Université de Sherbrooke
Estelle Desjarlais, Université du Québec à Montréal
Sophie Perron, Université de Sherbrooke

ABSTRACT
There is a limited amount of empirical research, particularly in primary education, where contextualization of science learning is a central subject of study. The research we conducted was to study the added value to science learning when students were immersed in natural environments immediately surrounding students' schools. We asked the following research question: How is science learning impacted when elementary students are immersed in the local contexts in which the natural phenomena occur? We recruited 4 classes of 5th and 6th grade students (n = 66) in an urban location. The students all experienced the same sequence of three teaching periods of two hours each, one period per week. The teaching sequences associated with this study aimed to teach scientific concepts related to the interactions between living organisms and their habitat. We used two data collection strategies: student drawing and individual interviews with students. The results suggest that contextualization of science learning outdoors in schools' immediate surroundings may add value, compared to indoor science learning, to learn about living organisms. One of the most unexpected results is the increase of students' environmental sensitivity after activities, even if it was not a targeted outcome.

Co-constructing a trans-systemic place-based environmental education model

Meena M. Balgopal, Colorado State University
Deepti Bhatt, Dakshin Foundation
Karishma Modi, Dakshin Foundation
Vani Sreekanta, Dakshin Foundation
Mythreyi Kumaraswamy, Dakshin Foundation
Kartik Shanker, Dakshin Foundation
Naveen Namboothri, Dakshin Foundation

ABSTRACT
When natural and social science researchers and practitioners collaborate, they can find meaningful ways to design and implement place-based education (PBE) that is locally meaningful for stakeholders. This study describes a Participatory Action Research (PAR) project between members of a non-government organization in India and a science education researcher. Our 6-month long PAR was driven by an interest to evaluate the PBE curriculum created by members of the organization. Through prolonged engagement, reading of PBE research papers, reviewing global sustainability education documents, co-leading teacher workshops, critiquing the organization's curriculum materials, our team gathered and analyzed a collective set of data, including our individual meeting notes, using critical discourse analysis. We co-constructed a trans-systemic PBE model that integrates natural, human-made, and human belief systems with the goals of helping stakeholders (K-12 students, teachers, fishermen, etc.) explore how an understanding of all three affect human choices that impact conservation and sustainability. Hence, our PAR affected how all of us acknowledged that a trans-systemic approach to PBE is more likely to help stakeholders achieve agency to change their local environments. We are currently testing our model and posit that this PBE model is relevant for contexts with diverse cultural belief systems.

Fostering relationships between elementary students and the more-than-human world: a nature center/school/university collaboration

Sarah R. Stapleton, University of Oregon
Kathryn Lynch, University of Oregon

ABSTRACT
We join scholars who criticize the social separation of humans and the more-than-human and argue that science education is an important site for students to be brought into relationship with the more-than-human world. We argue that an emphasis on the more-than-human world is complemented by place-based education within students' local community. The program studied in this paper is a collaboration between a university, elementary school, and nature center that have created field trips for students 3 times per year over their entire K-5 elementary career. Research questions from this phenomenological ethnography include: What impacts in children do we see from long-term repeated exposure to the same local and accessible place within the community? How do we "measure"/capture kids' moving toward a deeper relationship with the non-human?

Middle School Science Teachers' Motivations to Implement Place-based Education Curricula About Local Wildlife

Diane Susan Wright, Colorado State University
Meena M. Balgopal, Colorado State University

ABSTRACT
One curricular approach to environmental education (EE) is through place-based education (PBE) which uses the local context at the basis for creating learning opportunities for students about the natural and social structures within their community. PBE curricula involves educators with local experts in collaborative efforts to educate and encourage student civic engagement. In one city in the Rocky Mountain region, middle school science teachers were recruited to place remote camera traps near their school and use the camera data in their ecology unit along with standard aligned lessons. In this study, we examined how these teachers chose what resources to implement in their classroom using both PBE and Social Cognitive Theory to identify environmental (structural or cultural) and personal variables that explained which teachers implemented lessons, modified lessons, or overlooked lessons. Teachers' personal contexts and motivations outweigh structural contexts in decisions to engage students in PBE opportunities. For PBE curricula to be used as a method for advancing the goals of EE, educators need to be provided not only with opportunities but motivational factors to engage in local environmental and structural contexts.

Science Practice Pathways in Community-Based Environmental Education
Scott Byrd, Maine Mathematics and Science Alliance
Ruth Kermish-Allen, Maine Mathematics and Science Alliance
Alexandria Brasili, Maine Mathematics and Science Alliance

ABSTRACT
We use data from the [Hidden State] Survey for Environmental Education to gain a deeper understanding of educator implementation of environmental actions and science practices by employing social network analysis to understand the connections between those practices in programming facilitated throughout our state. The project is interested in learning how schools and organizations (including nonprofits, afterschool programs, land trusts, libraries, etc.) across the state are educating K-12 youth about the environment while also connecting them to their communities. Understanding how current high-mastery projects are connecting the two sets of practices in their work will contribute to the understanding of environmental education writ-large and help support efforts to train educators in facilitation and program design. Thus, our general research investigates how science inquiry and environmental actions practices interact or co-occur in projects. We analyze over 100 high-mastery environmental education projects to understand the incorporation of "crossover" practices that connect science inquiry with environmental actions. A correlation matrix of practice co-occurrence and a network graph of correlational links are displayed and unpacked. We find three distinct crossover pathways that give insight into how high-mastery projects facilitate crossover practices. Implications for professional development and further research are discussed.

Concurrent Session 4
10:30 AM-12:00 PM

Presidential Symposium
Admin Symposium-Citizen Science – an International and Integrative Look at a Scientific and Educational Method
10:30 AM-12:00 PM, Meadow Lark/Douglas Fir - 3rd floor

Citizen Science – an International and Integrative Look at a Scientific and Educational Method

Ayelet Baram-Tsabari, Technion - Israel Institute of Technology
Joseph L. Polman, University Of Colorado Boulder
Justin Dillon, University of Exeter
Heidi Ballard, University Of California Davis
Tali Tal, Technion
Arjen E.J Wals, Wageningen University, NL
Rikke Magnussen, Aalborg Universitet, Denmark

ABSTRACT
Citizen Science (CS) is an exciting and emerging type of public participation in research – it refers to the co-creation of knowledge by scientists and non-scientists who work together to advance research. Citizen science projects extend across various scientific disciplines from ecology and astrophysics to biochemistry and the humanities. CS has the potential to make science more inclusive and relevant and to advance public engagement with science. At the individual level, it allows scientists access to data collection and data analysis at grand scales, and to participants, it offers civic empowerment, a range of educational outcomes and the enjoyment of being part of a scientific endeavor. This session will bring together scholars interested in and doing CS from different countries. We will discuss theoretical ideas behind CS and why it responds to current need to engage the public in science, and demonstrate how various forms of collaboration between scientists and the public in general and students, in particular offer a range of opportunities to participate in the scientific endeavor.

Strand 1: Science Learning, Understanding and Conceptual Change

Engineering Framework

10:30 AM-12:00 PM, Salmon

Presider: Helen Semilarski, University of Tartu

Assessing Student Learning of Core Ideas and Practices from Participating in an Integrated Engineering Framework

Lawrence Chu, The University of Texas at Austin
Victor D. Sampson, University Of Texas At Austin
Todd L. Hutner, The University of Alabama
Richard H Crawford, The University of Texas at Austin
María González-Howard, University of Texas at Austin
Christina L. Baze, University of Texas at Austin
Catherine Riegle-Crumb, University of Texas at Austin

ABSTRACT
Engineering integration in K-12 science classrooms is meant to increase access to engineering for all students and to improve science learning, but evidence from existing studies shows mixed results. This paper explores the relationship between students' participation with science and engineering practices and their learning of core ideas and their ability to use those practices. This participation comes in the form of an instructional framework (Argument-Driven Engineering; ADE) used to integrate engineering into secondary science classes. An assessment, developed and validated for the purpose of measuring student learning of science core ideas and ability with engineering practices, was administered as a pre- and post-test to both a treatment group of middle school students that participated in the ADE framework (n=280) and a comparison group (n=214) that did not. Growth curve modeling revealed a

significantly larger increase in scores for the treatment group over that of the comparison group on one of two versions of the assessment. Findings suggest that students' engagement with the framework may have positively affecting their learning of and ability with certain core ideas and practices. They present implications for better understanding student learning and assessment in integrated science-engineering settings.

Kindergartners' Engagement in two Epistemic Practices of Engineering: Making Trade-offs and Applying Science

Pamela S. Lottero-Perdue, Department of Physics, Astronomy & Geosciences Towson University
Ming Tomayko, Department of Mathematics Towson University

ABSTRACT

This study examines the ways in which kindergartners (ages 6 and 7) engaged in two interrelated epistemic practices of engineering during their first design creation within a science-integrated design challenge: making trade-offs and applying science. After whole-class science investigations and the introduction of the design problem, 53 study participants across 5 classrooms in 3 schools were individually interviewed as they created fences using up to 10 foam and 10 wood blocks to contain a small robot. Video-recordings of the interview captured what participants did, made, and said as they created their first designs and answered questions about them. Iterative analysis of videos and transcripts led to the development and assignment of codes and sub-codes, which ultimately focused on participants' engagement in: making trade-offs between the size of fenced-in area and the block type used in the fence, and considering and applying ideas about inertia. Of the 51 participants who created a fence that encompassed an area, 33% made trade-offs. While 43% articulated relevant science ideas, only 12% also fully applied these ideas within their designs. This study contributes to the literature on epistemic practices of engineering as enacted by young learners and connected to science education.

Promoting and Evaluating Conceptual Development in Early Elementary Science Using Engineering Design and Multimodal Assessment

Christine McGrail, University of Massachusetts Amherst

ABSTRACT

This study investigated the use of engineering activities for promoting conceptual development in second grade science and introduced a multimodal learning progression rubric for evaluation of conceptual development. Students experienced three engineering design activities relating to force and motion. Design activities created a meaningful problem-solving context, and allowed students to work through alternate conceptions. The multimodal learning progression assessed students' initial and final understandings and tracked their progression towards scientific concepts across multiple modalities; oral, written, graphic, and gesture. Findings suggest that engineering design activities successfully promote conceptual development of science concepts in a diverse group of young children. The multimodal learning progression rubric demonstrated a low ceiling for prior knowledge perhaps due to children's increased access to technology-based resources.

Eliciting Students' Abstract and Multidisciplinary Thinking in a Design Review
Jenny P. Quintana Cifuentes, Purdue University
Senay Purzer, Purdue University

ABSTRACT
In engineering, design review sessions are a common practice. Yet, in education, their value in eliciting student thinking and reasoning is under-utilized. In this study, we analyzed data collected during a design review session. We captured conversations between two design reviewers and ten middle school students. We examined how the design reviewers' questions helped elicit students' explanations. The analysis focused on two dimensions of explanations: a) abstract-to-concrete thinking and b) multidisciplinary thinking. Our findings suggest that students with strong understandings of science and design principles illustrated transitions between dimensions while students with weak understandings relied on their experiential observations. Our findings also suggest that design reviewers' questions challenge students to transition across semantic dimensions so students can demonstrate their multidisciplinary knowledge and abilities to make concrete-abstract connections. We argue that design reviews are critical in eliciting student reasoning about design decisions and the effective integration of science and engineering.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Characterizing computational thinking in the context of technology-enhanced multilevel system modeling
10:30 AM-12:00 PM, Mt Hood

A framework for computational thinking in the context of system modeling
Daniel N. Damelin, The Concord Consortium
Joseph S. Krajcik, Michigan State University

Relationship between students' understanding and multi-level system modeling capability through the lens of computational thinking
Israel Touitou, Michigan State University
Emil Eidin, Michigan State University
Tom Bielik, Michigan State University
Namsoo Shin,
Joseph S. Krajcik, Michigan State University

Characterizing Progression of Computational Thinking Practices as Students Build and Revise Dynamic Models
Tom Bielik, Michigan State University
Emil Eidin, Michigan State University
Israel Touitou, Michigan State University
Joseph S. Krajcik, Michigan State University

Structural aspects of student dynamic models
A. Lynn Stephens, The Concord Consortium
Steve Roderick, The Concord Consortium

ABSTRACT
The science education community recognizes the importance of systems and systems models and computational thinking (CT) to help the next generation of learners engage in STEM-related fields and lead a more informed civic life. The goal of our research effort is to explore how students' CT develops over time through investigations of phenomena and system models of increasing complexity. We examined the progress of ~100 students' computational artifacts (system models) associated with their explanations of those models in 10th-grade science classes over a two-week instructional unit. The students constructed and iteratively revised their models while they learned new concepts using a system modeling tool that provides various ways to support systems modeling. The four papers in this related paper set work together to show 1) the CT framework in the context of system modeling practices, 2) How prior content knowledge and CT influence constructing an appropriate dynamic model 3) how students' understanding and CT evolve as they engage in system modeling practices, and 4) system models as a window into student conceptual thinking. The mixed-method qualitative and quantitative data results show that there is a need to scaffold building a system modeling throughout the unit in order to promote students' use of computational thinking skills and practices.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Motivation & Self-Efficacy
10:30 AM-12:00 PM, Hawthorne/Belmont/Laurelhurst
Presider: Elizabeth Hufnagel, University of Maine

Motivational and Instructional Factors Predicting Performance in Science: A Machine Learning Approach
Wondimu Ahmed, The University of Akron

ABSTRACT
The purpose of this study was to examine the role of motivational and instructional factors in predicting science performance among 15-year students in USA using machine learning approach. The data come from 5712 students in the USA who participated in PISA 2015. The results of our strongly data driven approach indicated that disciplinary climate and enjoyment of science play a significant role in predicting science performance even when relative grade (proxy for previous performance) and socio-economic index were considered. More importantly, the findings indicated that there are multiple novel interactions between motivational factors and instructional factors that need to be considered in predicting science performance.

The Relationships Between Hormones and the Motivation of Adolescents to Learn Science
David L. Fortus, Weizmann Institute Of Science
Ella Ofek-Geva, Weizmann Institute of Science
Michal Vinker, Samson Assuta Ashdod Hospital
Tevie Mehlman, Weizmann Institute of Science
Alexander Brandis, Weizmann Institute of Science
Yonatan Yeshayahu, Samson Assuta Ashdod Hospital

ABSTRACT
While students tend to enjoy science learning at a young age, as they mature they become less motivated to engage with science (Archer et al., 2010). Why is this? The contributions of science teachers/curriculum/school/parents/peers and other environmental factors have been investigated, yet there is still no comprehensive explanation. No doubt the environment is a huge influence, but it is

possible that there are also physiological factors at play. During adolescence/puberty the endocrine system undergoes significant changes. Hormones play an important role in the development of the adolescent. In particular: DHEA-S, estrogen and testosterone are worth studying in the context of cognitive and socio-emotional behavior (Ebner, Kamin, Diaz, Cohen, & MacDonald, 2014). We investigated the relations between these key hormones and adolescents' affect towards science. Our initial results are promising and support a new perspective on motivation development that is presented here for the first time. The more puberty progresses, as indicated by higher levels of testosterone or estrogen, the lower girls' interest in science, self-efficacy towards science, and their motivation to engage with science, as indicated by lower levels of mastery and performance orientation towards science. This study presents a new mechanism that can contribute to this decline.

Self-Assessment and Underrepresentation in AP Physics 1

Marta R Stoeckel, University of Minnesota

ABSTRACT

White women and people of color are underrepresented at multiple levels of physics education. One avenue for understanding the experiences that perpetuate underrepresentation is self-efficacy, which women tend to report a much lower sense of than their male peers (Jurik, Gröschner, & Seidel, 2013; Marshman, Kalender, Nokes-Malach, Schunn & Singh, 2018; Mujtaba, & Reiss, 2013; Nissen & Shemwell, 2016). This mixed-methods study examines self-efficacy and the experiences of underrepresented students in an AP Physics 1 classroom. Students were asked to predict their score on in-class assessments, then, over two years, these predictions, as well as students' actual scores, were collected and plotted onto a CCL Confidence Achievement Window (Covington Clarkson, Love, & Ntow, 2017). These results showed no significant difference in the self-efficacy between boys and girls enrolled in the course or between white students and students of color. During the second year, written student responses to an open-ended prompt on each assessment were also collected and a subset of students were interviewed to determine what kinds of classroom activities were particularly impactful. Labs were identified as having both a positive and negative effect on students' self-efficacy with peer-to-peer interactions being especially critical to students' beliefs about their abilities.

Tales of learning science in and out of school between ages 9-13

Ella Ofek-Geva, Weizmann Institute of Science
David L. Fortus, Weizmann Institute Of Science

ABSTRACT

While students tend to enjoy science at a young age, as they grow older they become less engaged with science. This decline in motivation for science has been documented in several studies and is evident in many countries, with little difference between genders. On the other hand, studies have shown that a career choice in science often begins to develop at a young age. The goal of this study was to provide rich descriptions of the development of individual students' interests in, attitudes toward, aspirations, and motivation to engage with science, during early adolescence. The study used a mixed-methods approach. Students who had a strong intrinsic motivation for science or science-supporting parents seemed more resistant to and tolerant of the gap between science as portrayed in the classroom and their personal vision of science. These students find explanations for the classroom reality, even though they disagree and dislike it. They distinguish fulfill their need for "real" science in other places. Other students, who do not have this protective layer, do not distinguish between school science and "real" science, are disenchanted by school science and have no motivation to engage any further with science.

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

Critical Factors for Effective and Equitable NGSS Science Teaching Practices

10:30 AM-12:00 PM, Salon E

Teachers' Variable Subject Matter Knowledge and Inquiry-based Instruction

Lyrica Lucas, University of Nebraska–Lincoln
Elizabeth Hasseler, University of Nebraska - Lincoln
Amy Tankersley, University of Nebraska-Lincoln
Elizabeth B. Lewis, University of Nebraska–Lincoln
Brandon Helding, Boulder Learning, Inc.

NGSS-aligned Science Lesson Exemplars

Elizabeth Hasseler, University of Nebraska - Lincoln
Elizabeth B. Lewis, University of Nebraska–Lincoln
Lyrica Lucas, University of Nebraska–Lincoln
Amy Tankersley, University of Nebraska-Lincoln

Connections between Teacher and Classroom Variables and use of NGSS Scientific Practices

Amy Tankersley, University of Nebraska-Lincoln
Lyrica Lucas, University of Nebraska–Lincoln
Elizabeth B. Lewis, University of Nebraska–Lincoln
Elizabeth Hasseler, University of Nebraska - Lincoln

Science Teachers' Professional Development and its Effect on Inquiry-based Instruction

Elizabeth B. Lewis, University of Nebraska–Lincoln
Amy Tankersley, University of Nebraska-Lincoln
Elizabeth Hasseler, University of Nebraska - Lincoln
Lyrica Lucas, University of Nebraska–Lincoln
Brandon Helding, Boulder Learning, Inc.

ABSTRACT

With the Next Generation Science Standards, researchers must understand which science teacher characteristics and ecological factors support advancing such reform initiatives. In a 4-year longitudinal study of beginning and mid-career science teachers we adopted a multi-method approach to investigate effective and equitable instructional practices. We analyzed transcripts, administered a professional development survey, observed science lessons, and documented weeks of lessons. We posed research questions about teachers' subject matter knowledge and use of inquiry-based instruction (Paper #1), the use of NGSS scientific practices in science lessons (Paper #2), classroom diversity as it related to teachers' use of inquiry-based instruction (Paper #3), and finally, how a range of professional development (PD) activities contributed to teachers' use of inquiry (Paper #4). Findings included: (a) SMK measures by subject area contributed to explaining variability in teachers' inquiry-based instruction; (b) summaries of exemplary NGSS-aligned science lessons demonstrated how teachers taught in diverse classrooms;(c) teacher and classroom variables influenced teachers use of scientific practices (examples of how those practices were integrated into the classroom); and (d) science teachers needed to go out of districts to gain content-specific PD and their total amount of PD contributed significantly to continued improvements in teaching science.

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

Socioscientific issues in the science classroom

10:30 AM-12:00 PM, Salon D

Presider: Heidi Cian, Florida International University

Exploring Science Teachers' Pedagogical Design Capacity for Citizenship

Ineke Henze-Rietveld, Delft University Of Technology
Durdane Bayram-Jacobs, Department of Science Education, Radboud University, Nijmegen, The Netherlands
Erik Barendsen, Radboud University & Open University

ABSTRACT

This paper explores science teachers' PDC when designing lessons regarding informed decision making on current SSI, with the purpose of informing future development of professional development activities. The study took place in the context of a series of 8 workshops focusing on the goals of citizenship education. Our research question is: How can the teachers' PDC used when designing citizenship lessons be characterized in terms of goals, personal resources and instructional resources? This explorative multiple-case study involves three science teachers in different subjects (biology, physics, chemistry) on different schools. The data was collected through 4 teacher interviews. A qualitative content analysis was performed using Atlas.ti. The teachers in the study initially emphasize different goals on informed decision making as a citizenship competence. Personal resources determined the design process to a great extent for all teachers. The teachers' prior teaching experience turned out to be important. With respect to instructional resources, all three teachers extensively used the internet as a resource, school tv, scientific reports and lesson materials, etc. These materials were either adapted or used as starting points for inspiration or improvisation. Our study concludes that science teachers can design citizenship lessons when providing them with relevant instructional resources.

Secondary Science Teachers Implementation of a Curricular Intervention when Teaching with Global Climate Models

Kimberly Carroll Steward, University Of Nebraska - Lincoln
Devarati Bhattacharya, University Of Nebraska
Cory T. Forbes, University Of Nebraska–Lincoln
Mark Chandler, NASA-GISS Columbia University

ABSTRACT

There has been increasing emphasis on promoting 'climate literacy', particularly among students in formal K-16 classroom settings, in the last decade. Teachers play a critical role in cultivating these opportunities for students, particularly in secondary science classrooms. However, the majority of prior climate education research has focused on students and student learning and, as such, little is known about how teachers implement these climate-focused curricular interventions (Monroe et al., 2017). Here, we report findings from research on four secondary science teachers' implementation of a climate education module grounded in the use of a data-driven, computer-based climate modeling tool to address the following research questions: 1) how do teachers implement the curriculum? and 2) why do teachers implement the curriculum in ways that they do? Results illustrate differences in how the four

teachers implemented the curriculum module, as well as their reasoning for making observed instructional decisions. Findings have important implications for the design of effective secondary science teaching and learning environments. The environments are critical in supporting students' model-based reasoning about Earth's climate and GCC. Additionally, findings are essential for future curriculum development and teacher support.

The Influence of Context: Comparing High School Students' Socioscientific Reasoning by Socioscientific Topic

Heidi Cian, Florida International University

ABSTRACT

Socioscientific issues (SSIs) are powerful tools to use in classrooms to support development of argumentation skills and scientific literacy through socioscientific reasoning (SSR). These skills are particularly important for high school students as they learn to exercise new-found freedoms and independence acquired as they begin driving, voting, and working. However, many teachers may be reluctant to use controversial issues such as SSIs in their classroom. The purpose of this study is to provide recommendations that may make using SSIs in high school classrooms easier through evaluation of how SSR may differ depending on the topic of the SSI. I compare aspects of SSR for two topics- environmental preservation and genetic screening-to demonstrate that students do approach these topics differently, and those differences may be accounted for by differences in levels of content knowledge and personal exposure to the issues. The results imply the need for different scaffolds to support SSR depending on the SSI. Additionally, they suggest the need for authentic learning associated with SSIs and highlight the value of classroom diversity in supporting growth in SSR for all students.

What Factors Do Secondary Students Consider When Making Decisions Across Multiple Socioscientific Issue Topics

Dawnne M. LePretre, Illinois Institute of Technology
Norman G. Lederman, Illinois Institute Of Technology

ABSTRACT

Linking science and action is the epitome of scientific literacy (Hurd, 1972; Kuhn, 1972; Watson, 1969). Students need to balance subject matter knowledge, personal values, and societal norms in decision-making (DM) on Socioscientific Issues (SSI) (Aikenhead, 1985; Kolstø, 2001; Ratcliffe & Grace, 2003; Zeidler et al., 2005). Students in grades 10-12 were recruited from seven schools and ten regular science classrooms primarily located in a large Midwestern city (n=468). The sample was roughly 50% of each gender and 33% of each grade level. Across the 60 enacted SSI lessons on six different topics, multiple sources of data were collected, including student artifacts, audio-tapes of class discussions and interviews, field notes, and teacher surveys. The minimum of three lessons were implemented for one to nine weeks for an average of 115 minutes per topic. Decision-making differed across the larger sample of students indicating that 10th – 12th-grade students used both general and specific factors when making decisions. Further, trends emerged, indicating various student groups' valued DM factors differently. Overall, 15 DM factors emerged that students considered when making decisions across multiple SSI contexts. Each specific SSI context had between one and 15 specific DM factors cited by students in this study.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Fostering students' communication and argumentation
10:30 AM-12:00 PM, Salon C
Presider: Jessica Karch, University of Massachusetts Boston

Discourse Remixed: Using interdependency to shift science learning through talk
Joshua Premo, Utah Valley University
Andy Cavagnetto, Washington State University
Larry Collins, Washington State University
William B. Davis, Washington State University
Erika Offerdahl, Washington State University

ABSTRACT
Increasing student engagement with social practices of science (communication, collaboration, and critique) is a goal throughout K-16 science education. Yet how different classroom environments promote productive forms of discourse, that result to greater learning, remains unclear. This study examined how task interdependence shifted student discourse and thus learning. 78 groups (interdependency = 50, comparsion = 28) of undergraduate students completed collaborative learning activities, either through jigsaw-like structuring or unstructured common practice, before completing a content assessment. 3,628 student talk turns were each coded and analyzed. Results showed that student presence in the interdependency condition predicted significantly higher assessment performance ($p< .05$, $R2= .04$) when controlling for overall course performance. Examinations of discourse found that both higher performing groups, and those in the interdependency condition, demonstrated significantly higher rates of providing scientifically accurate ideas and justification of their ideas. The "in common" nature of these differences suggest that the interdependency intervention may promote learning through shifting idea accuracy and justification during discourse. How this finding contributes to our understanding of discussion quality as an underlying factor impacting science learning in groups and our ability to use the intervention to encourage student engagement with social aspects of science is discussed.

Self-efficacy in Scientific Oral Communication: Exploratory Study with Postsecondary Science Students
Caroline Cormier, Cégep André-Laurendeau
Simon Langlois, Cégep Marie-Victorin

ABSTRACT
Self-efficacy (S-E) is at the basis of motivation. For sometimes stressful activities such as oral presentations, if students' S-E is low, their motivation to engage may also be low. Nevertheless, oral communication is an important skill for students to develop but few opportunities to practice this skill exist in postsecondary classes. In science, the aspect of scientific communication, with its particular codes and specialized terms, is yet another challenge for students. In this study, we sought to measure the S-E in oral communication of postsecondary science students. To do so, the questionnaire Perception and Attitudes towards Oral Communication in Science (PAOCS) was developed and validated. In the fall of 2018, 1,292 postsecondary science students answered the instrument. Data showed two distinct aspects of S-E, one related to the norms and content of an oral presentation in science and the other related to the quality of the presentation itself, or the "showmanship". Correlation between these factors and other factors measured by the PAOCS show that showmanship is more correlated to

enjoyment and anxiety than S-E related to norms and content. Interviews with students allowed a deeper understanding of the impact of past experiences on their S-E in oral communication.

The Effect of Argumentative Writing to Promote Nonscience Major Students' Learning in an Chemistry Course.

Claudia P. Aguirre-Mendez, Emporia State University
Ying-Chih Chen, Arizona State University
Takeshi Terada, Arizona State University

ABSTRACT
The purpose of this study is to examine the impact of argumentative writing assignments on nonscience major students' chemistry conceptual understanding. The participants of this study consisted of 163 students in the treatment group and 77 of the control group. A comparison of the pre- and posttest results indicated that students who engaged in argumentative writing tasks performed better than students who did not. Another result indicates that the most students are exposed to argumentative writing, the better the quality of the writing assignments. The results also indicate that mostly students' perception of the writing assignment were positive regarding their content knowledge and argumentative understanding. Students also value the integration of simulation to promote their engagement in the process of argumentation. Implication for instructors and students of the implementation of this instructional strategy will be discussed.

The use of problem typology for the promotion of argumentation among undergraduate engineers

Randy K. Yerrick, University At Buffalo
Andrew Olewnik, University at Buffalo
Yonghee Lee, University at Buffalo
Amanda Simmons, University at Buffalo
Brian Stuhlmiller, University at Buffalo

ABSTRACT
In the shifting seas of the shift towards the Next Generation Science Standards float the potential constructs of argumentation, science and engineering practices, and problem design. Much of the existing engineering education research literature point to frameworks for teaching and learning separate and isolated from contextual, sociocultural factors, and situating problem solving. We explore the development of argumentation among engineering students during their senior year practicum. Using the learning frameworks of Kolb (2005) and Jonnasen (2000) we studied students' argumentation through pre-post interviews, problem solving sessions, and collaborative group learning sessions. Students demonstrated significant uptake in the use of typology in spontaneous and sustained problem solving. Implications for teaching and research are discussed.

Strand 6: Science Learning in Informal Contexts

Museum participant experiences

10:30 AM-12:00 PM, Salon F
Presider: Katherine Carr Chapman, Vanderbilt University

A New Generation of Science Educators and Communicators: Unexpected Career Aspirations in Museum Program Participants

Kathryn Rende, North Carolina State University
Gail Jones, North Carolina State University
Emma J. Refvem, North Carolina State University
Megan Ennes, University of Florida
Pamela Huff, North Carolina State University

ABSTRACT

There is a growing need for science educators and communicators who can support public understanding of complex science issues. Across the United States, science museums increasingly offer volunteer positions to youth, allowing them opportunities to work in a variety of educational programming or research experiences. These programs are often designed to encourage youth to pursue STEM careers but may also have the added effect of inspiring the next generation of science educators and communicators. This study examined how youth volunteer experiences influence career aspirations. Twenty-one participants were interviewed about their experiences volunteering in a science museum during high school. Data were coded for factors related to social cognitive career theory (competence, performance, recognition, science self-concept, science interest, and career decisions). Results showed that in addition to STEM career goals, participants aspired to careers in science communication (95.2%), teaching science in K-12 settings (47.6%), and teaching in informal science settings (76.2%). Findings additionally suggests this aspiration leads to action, with 85.8% of participants stating that they are currently working in or currently pursuing careers directly or indirectly related to science teaching and communication.

CoP at a Museum to Support Early Childhood Teachers' Identities as Teachers of Science

Jenny D. Ingber, American Museum of Natural History
Jacqueline Horgan, American Museum of Natural History
Veena Vasudevan, American Museum of Natural History

ABSTRACT

Teachers, as the primary curators of learning in preschool settings, greatly affect young children’s access to science learning. Quality professional learning (PL) has the potential to shift teachers’ self-perceptions by developing content knowledge, skills of inquiry and collaboration, and self-efficacy (Avalos, 2011). Further, PL in out-of-school settings, like museums, can be integral to support teachers of early childhood science learning (Luehmann & Markowitz, 2007; National Research Council, 2007). In this study we sought to determine the ways in which preschool teachers' participation in professional learning at a Museum supported their identities as teachers of science. The professional learning used Wenger’s (1998) communities of practice (CoP) as a guide for creating shared learning experiences for the preschool teachers. Shifts were observed in teachers' participation in the PL, in the ways in which they saw the world ("science is everywhere"), and in the way they perceived themselves and their abilities to teach science.

Embodied Interaction in a Science Museum
Neta Shaby, Ben-Gurion University Of the Negev, Israel
Dana Vedder-Weiss, Ben-Gurion University Of the Negev, Israel

ABSTRACT
Science museums offer a variety of experiences, interactions, participation modes and roles. Nevertheless, most studies address museum visitors' talk and derive more from an interest in social-cognitive processes than in embodied disciplinary practices and communication. In this study, we explore the ways by which visitors' bodies participate in their interaction with each other and with the exhibits at a science museum. We have analysed two and a half hours of video recordings of students' visits to a science museum. We applied multimodal linguistic ethnographic microanalysis methods, using the Embodied Participation Framework (Goodwin, 2007) as our analytic lens. Our analysis reveals four ways by which the body participates in the interaction: (1) manipulating the exhibit; (2) communicating, collaborating, and coordinating; (3) social positioning and identification; and (4) sense-making. This study advances the understanding of interactions in science museums by directing attention to the physical interaction, rather than focusing solely on verbal interaction, and thereby highlighting the role of embodiment. This research also offers a methodological contribution: an illustration of the ways in which video-based field studies coupled with a relevant multimodal analytic framework can explore the social and interactional organization of engagement with objects in informal science learning environments.

Impacts of museum tour interpretation on visitors' post-visit marine conservation behaviors and transformative learning
Yi Ting Pan, Institute Of Education, National Sun Yat-sen University
Kuay-Keng Yang, National Pingtung University
Zuway-R Hong, National Sun Yat-Sen University
Huann-Shyang Lin, National Sun Yat-Sen University

ABSTRACT
The objective of this study focused on how the effect of the interactive interpretation in the marine museum on the change of visitors’ interrelatedness toward the marine environment and post-visit environmental behaviors. The data collection includes three stages that this study focused on the post-visit behaviors. There were 284 visitors who completed the on-site survey, 43 visitors and 10 visitors participated in the follow-up survey of on-line questionnaire and in-depth interview, respectively. Results suggested that visitors who are more connecting to marine environment, topic-related interest, and marine conservation intentions during their visit, tend to have high level of post-visit behaviors, especially on public conservation behaviors. In-depth interview also supported the result that emotional interpretation content would have opportunity to inspire visitors’ empathy, especially on family visitors with kids. These findings reveal the importance of delivering effective strategy through a short marine topic-related learning.

Strand 7: Pre-service Science Teacher Education
Building Preservice Teacher Capacity through Stakeholders
10:30 AM-12:00 PM, Salon A
Presider: Frackson Mumba, University Of Virginia

The Elementary Science Partnership: An Evolving School-University Collaboration Around a Pre-Service Science Methods Course
Jerome M. Shaw, University of California - Santa Cruz
Samuel Severance, University of California, Santa Cruz

ABSTRACT
Providing pre-service elementary teachers with rich learning opportunities within the context of single-offering, short timeframe science methods courses remains an ongoing challenge for preparing elementary teachers to teach science. This study examines the Elementary Science Partnership (ESP), a three-year university-school collaboration wherein an elementary science methods course was embedded in two local elementary schools whose campuses served as not only the site for practicum experiences but also hosted all methods course activities. The design and implementation of the ESP's evolving model draws on integrated conceptions of science learning and "knowledge-in-use" perspectives of science learning. The high English Learner demographics of the partner schools provided opportunities for pre-service teachers to observe and engage in science teaching and learning that benefits culturally and linguistically diverse students. Thematic analysis of participant responses to an annual survey revealed a variety of affordances and constraints, informed iterative revisions to the partnership's model, thus providing insights and practical approaches to joint work in support of students' science learning in an authentic setting.

Shifting Teacher Preparation for NGSS: Using a Networked Improvement Community to Promote Change Across Contexts
Michelle L. Sinapuelas, California State University, East Bay
Corinne H. Lardy, California State University, Sacramento

ABSTRACT
A Networked Improvement Community (NIC) of 11 science education faculty from six universities was formed to facilitate communication and shared expertise among faculty working towards a common goal of improving preservice teacher understanding of NGSS within science methods courses. Over the course of three academic years NIC faculty were studied to evaluate the impact participation had on their understanding of NGSS and instruction in the science methods course they taught. Faculty became more confident with instruction for preservice teachers on how the components of NGSS can be integrated to align instruction with NGSS. This paper includes characterization of how the NIC was formed, discussion of how participation impacted faculty, and suggestions of how this model could support further efforts.

Using Expectation Violation Theory to Determine the Three Stakeholders' Expectations from the Teaching Experience Course based on Clinical Supervision Model
Tugba Yuksel, Recep Tayyip Erdogan University
Banu Avsar Erumit, Recep Tayyip Erdogan University

ABSTRACT
This study aimed to identify expectations of stakeholders (pre-service teachers, supervisor teacher, and mentor faculty) from the process of field experience classroom and from each other. We used Expectancy Violation Theory as our theoretical framework to determine the expectations of those three stakeholders from each other and identify contradictions among these expectations. The sample of this study consisted of eighteen senior pre-service science teachers (5 focus groups) enrolled in the science education program, five mentor faculty members, and four in-service middle school science teachers.

Data collection tools included semi-structured focus groups interviews with pre-service teachers, semi-structured one-on-one interviews with the faculty members, and interview form that contain open-ended questions sent to the teachers. The results of the interviews conducted in this study showed that the pre-service teachers had more expectations from supervisor teachers. Similarly, faculties and supervisor teachers' expectations concentrated on pre-service teachers. Some expectations such as not the call teacher candidates as intern and giving elaborate feedback to teacher candidates' lesson plans were common among three of the stakeholders, some of them such as giving the same opportunities to teacher candidates as teachers in the school and the relationship between teacher candidates and supervisor teachers were violated.

Strand 7: Pre-service Science Teacher Education

Preservice Teaching Practices

10:30 AM-12:00 PM, Salon B

Presider: Michelle Forsythe, Texas State University

Using Rehearsals with Teacher Educator Feedback to Support Preservice Teachers' Vision of Ambitious Science Teaching

Amanda Benedict-Chambers, Missouri State University

ABSTRACT

This study investigated preservice teachers' noticing of ambitious science teaching in the context of rehearsals with teacher educator feedback in an elementary science methods course. Analyses of TE feedback from 21 rehearsals and 80 reflections indicated that preservice teachers focused on how to improve the ways they supported student thinking of disciplinary core ideas and supported students' access to science practices in their rehearsal and classroom lesson reflections. In fact, preservice teachers privileged ways to support student thinking in their reflections even when the teacher educator's feedback did not emphasize student thinking in their particular rehearsal. These findings suggest that rehearsals with teacher educator feedback have the potential to support collective learning in a methods course and to help preservice teachers learn to notice and make informed decisions about how to make their instruction more ambitious.Implications for the design of practice-based methods courses to prepare preservice teachers to develop a vision of ambitious teaching are discussed.

Probing The Myth: Are Cognitive Abilities And Modeling Processes Really Related?

Maximilian Göhner, Freie Universität Berlin
Moritz Krell, Freie Universität Berlin

ABSTRACT

Modelling is highlighted as a central scientific practice in current research and curricular documents worldwide, but its integration in classrooms poses challenges. Various cognitive and meta-cognitive abilities, e.g. meta-modeling knowledge (MMK), scientific reasoning competencies (SRC) and general cognitive abilities (GCA), are assumed to be positively related with sophisticated modeling processes. To investigate these relations, 32 pre-service science teachers were filmed engaging in a blackbox modeling task. Following a qualitative content analytic approach and using a category system, each participant's modeling process was split into 19 different modeling activities. Based on the resulting sequences, each participant was assigned to one of four modeling strategies (e.g. exploration and model development or exploration, model development and predictions drawn from the model). The participants' MMK, SRC and GCA were assessed with established paper-pencil based instruments. While SRC was positively

related to MMK (r=.56; p<.01) and GCA (r=.44; p<.05), no systematic relations could be found between the modeling strategies used and the test scores. These findings question the empirical validity of established assumptions held by many science education researchers (e.g. MMK guides modeling practices) and demonstrates the need for further research to develop educational interventions, aiming to foster modeling competencies.

An Investigation of Preservice Elementary Teachers Reaction to Integrating Computational Thinking in Their Teaching

Diane Jass Ketelhut, University Of Maryland
Randy McGinnis, University Of Maryland
Kelly M. Mills, University of Maryland
Merijke Coenraad, University of Maryland
Lautaro Cabrera, University of Maryland, College Park
Heather Killen, University of Maryland College Park

ABSTRACT
The goal of our research project was to develop and test a module for an undergraduate elementary science teacher methods course that is designed to prepare preservice teachers (PSTs) to include computational thinking (CT) in their classroom science teaching practices. The rationale for our research is policy driven because our state was an early adopter of The Next Generation Science Standards (NGSS). For the first time, the NGSS includes CT as a Core Science and Education Practice. This has spurred immediacy in the field's interest in learning more about CT, especially how to prepare science educators (teacher educators and classroom practitioners) to teach it to all learners and, in particular to those underrepresented in STEM. The study qualitatively examined PSTs' confidence to meaningfully include CT in their lesson plans and their success in doing so. Findings indicated four groups of PSTs: those that expressed confidence in integrating CT and were successful based on lesson plan analysis, those who were hesitant and were unsuccessful, and those whose confidence and success were incoherent. The largest group was those who were 'cautiously optimistic.' Interpretations of these results and implications for science teacher preparation and elementary education are included.

Impact of a Phenomenon-Based Science Workshop on Prospective Elementary Teachers' Science Content Knowledge

Martha M. Canipe, Northern Arizona University
Lucas Mulcahy, Northern Arizona University
Maggie Reid, Northern Arizona University

ABSTRACT
An enduring and well documented challenge for elementary science teachers is that their science content knowledge is often incomplete in relation to the content that they are expected to teach in their classrooms. Previous research on inquiry-based science content courses for prospective teachers has shown that these courses can be effective in improving content knowledge. The concurrent mixed methods study described here built on that idea and investigated the impact of a phenomenon-based science content workshop on prospective elementary teachers. The findings showed that not only did the prospective elementary teachers improve their content knowledge as measured by a multiple-choice test, they also developed more sophisticated scientific ideas that they were able to use to develop an explanatory model of a scientific phenomenon.

Strand 8: In-service Science Teacher Education
Meeting the Content Needs of STEM Educators
10:30 AM-12:00 PM, Pearl
Presider: Kathryn N. Hayes, California State University, East Bay

A Needs Assessment of Central California Science Teachers: Professional Development Challenges & Opportunities
Alexandria K. Hansen, Fresno State
Quinn Camara, Fresno State University
Prabhjot Kaur, Fresno State University
Anahi Martinez

ABSTRACT
This study reports on our experiences surveying secondary science teachers in the areas surrounding our university with the larger goal of identifying professional development (PD) needs. Survey items were selected from the National Survey for Science and Mathematics Education (NSSME) conducted by Horizon Research Group. Using a nationally available, validated instrument afforded the opportunity to compare our regional teaching workforce to the national sample. We found that science teachers in Central California hold contradictory beliefs about reform-oriented and traditional teaching approaches. Further, despite attending PD within the last three years, only half of the teachers received effective PD and even fewer received student-centered PD. These differences indicate potential challenges for science teacher educators working to transition to the NGSS and provide future directions for PD efforts in the areas surrounding our university.

Adapting Professional Development for Urban Science Teachers by Foregrounding the Educator's Perspective
Darrin A Collins, University of Illinois at Chicago
Julio Mendez, University of Illinois at Chicago
Jennifer Olson, University of Illinois at Chicago
Miiri Kotche, University of Illinois at Chicago

ABSTRACT
Science teacher education programs are vital in supporting new and seasoned teachers to strengthen their instructional practice and identities as scientists (Kane & Varelas, 2016; Maulucci et al., 2015). The university program at the center of this study seeks advance science teacher Pedagogical Content Knowledge through purposeful partnering between faculty in the College of Engineering and the College of Education. The purpose of this research is to examine teachers' perspectives of this bioengineering program in the first three years of implementation. This study was designed to discover trends of the bioengineering program that have a positive impact on teacher participants' development of Pedagogical Content Knowledge (Creswell, 2012). Three years' worth of data was collected using a qualitative descriptive study employing open-ended survey questions. Data trends in the surveys indicated that teachers identify three consistent aspects of the program that promoted their ability to develop Pedagogical Content Knowledge: the importance of collaboration, background research, and ongoing feedback. Teachers also identified three key themes that hindered their development of Pedagogical Content Knowledge: a lack of background knowledge in software, complexity of bioengineering concepts, and adapting to the research environment.

Construction of STEM literacy and Chinese Teachers' Understanding

Xiao Huang, Zhejiang Normal University
Sibel Erduran, University of Oxford
Kang Kang Luo, Zhejiang normal university
Sa Piao Zhang, Zhejiang normal university

ABSTRACT
STEM education has increasingly become an important area in addressing scientific literacy. In context of China, similar trends in STEM education advocacy can be observed although very few studies have addressed the issue from teachers' perspective. The aim of the research is to develop the framework of STEM literacy and assess Chinese teachers' STEM understanding. Based on Zollman's& Bybee's definition of STEM literacy, the framework which include STEM knowledge, STEM ability and STEM attitude was developed. Then, 93 compulsory education teachers of different subject Participated in the survey of STEM literacy. Based on the data analysis, the conclusions are as follows: (a) Teachers performed better in the engineering knowledge， and the problem-solving ability was fairly limited; (b) There were gender significant differences in engineering knowledge and mathematics knowledge; (c) The attitudes toward STEM education might have no correlation with teachers' understanding of STEM knowledge.

Retaining Science Teachers: A Mixed-Methods Study on the Relationship Between Professional Development and Retention

Kathryn N. Hayes, California State University, East Bay
Linda Preminger, Teacher, San Lorenzo District
Christine L Bae, Virginia Commonwealth University

ABSTRACT
The negative impacts of high teacher turnover are widely documented, with particular impact on low-income, high-minority schools. Turnover can be especially widespread in science education, where teachers are in high demand. Although teacher retention is predicated on job satisfaction, which is in turn fostered by opportunities for professional growth, little research has been conducted on the relationship between professional development and retention. In order to investigate this relationship, we conducted a mixed methods study to first quantitatively determine the relationship between professional development and retention, and then qualitatively investigate the nature of the relationship. The results demonstrate a complex relationship, in which professional identity, professional development, and agency contribute iteratively to teachers remaining in middle school science teaching.

Strand 10: Curriculum, Evaluation, and Assessment

Socio-scientific Issue and Model Based Learning (SIMBL): Advances in Research to Inform Practice and Theory

10:30 AM-12:00 PM, Columbia

Discussant: Vaille Dawson, University Of Western Australia

Co-Designed Socio-Scientific Issues-Based Curriculum Unit Implementation: A Case of Secondary Science Teacher Learning
Patricia J. Friedrichsen, University Of Missouri–Columbia
Li Ke, University of North Carolina, Greensboro
Troy D. Sadler, University of North Carolina at Chapel Hill
Laura Zangori, University Of Missouri
Vaille M. Dawson, University Of Western Australia

Students' Perceptions of Socio-Scientific Issue-Centered Learning and Their Appropriation of Epistemic Tools for Systems Thinking
Li Ke, University of North Carolina, Greensboro
Troy D. Sadler, University of North Carolina at Chapel Hill
Patricia J. Friedrichsen, University Of Missouri–Columbia
Laura Zangori, University Of Missouri

Developing Systems Thinking through Modeling in the Context of Socio-Scientific Issues among Elementary Learners
Laura Zangori, University Of Missouri
Li Ke, University of North Carolina, Greensboro
Troy D. Sadler, University of North Carolina at Chapel Hill

Supporting Socio-Scientific Issues Teaching and Learning with Computational Thinking
Amanda N. Peel, Northwestern University
Patricia J. Friedrichsen, University Of Missouri–Columbia
Troy D. Sadler, University of North Carolina at Chapel Hill

ABSTRACT
Socio-scientific issues (SSIs) have been used as contexts for science education for several decades, and over the past five years, our team has worked to advance new frameworks for using SSIs in classrooms and strategies for supporting science teachers as they incorporate issues in their instruction. We conceptualize this work as necessarily addressing multiple dimensions of science education including curriculum development, teacher education, student learning, and classroom practices. In this paper-set, we share a set of related studies that address different aspects of our efforts. The first study explores how teachers take up SSI teaching practices. The second paper investigates high school student responses to SSI teaching approach and how they appropriate epistemic tools for negotiating complex issues. The third investigation examines how modeling can be used to support elementary students' systems thinking. The final study explores how students can engage in computational thinking to develop understandings of SSI. The presentation will begin with an orientation to the theoretical perspectives that guide the work. Next, authors from each of the papers will share highlights of their studies. Finally, a discussant will facilitate a conversation about where the field should move in terms of research and practice.

Strand 11: Cultural, Social, and Gender Issues

Grappling with Coming Closer to Equity and Justice in Science Education: Students and Teachers Pondering Identities, Engaging in Multimodal Representations, and Pursuing Critical Hope

10:30 AM-12:00 PM, Salon I

Presider: Maria Varelas, University Of Illinois At Chicago

Grappling with Coming Closer to Equity and Justice in Science Education: Students and Teachers Pondering Identities, Engaging in Multimodal Representations, and Pursuing Critical Hope

Maria Varelas, University Of Illinois At Chicago
David Segura, Beloit College
Eli Tucker-Raymond, TERC
Christopher G. Wright, Drexel University
Rebecca Kotler, University of Illinois at Chicago
Brezhnev Batres, University of Illinois at Chicago
Nina Hike, University of Illinois at Chicago
Darrin Collins, University of Illinois at Chicago
Tiffany Childress Price, University of Illinois at Chicgao
James Klock, University of Illinois at Chicago

ABSTRACT

New and seasoned scholars in two big cities will share research focusing on ways in which practitioners and scholars grapple with the ever louder call for making science education matter in the lives of peoples who regularly face injustices, oppression, and domination. Embracing the Freirean view of education as a liberating process implies that learning science should be about making sense of what is happening in the world and participating in its transformation. Students need ways to be identifying dominant structures and agentically push back against them. As this process unfolds, students' and teachers' identities vis-a-vis the science practice are individually and collectively developed as they engage in activities over time in the various communities in which they simultaneously participate, and as they reflect upon their past, present, and future, using multimodal tools. Ten studies will be presented interactively via summaries, posters, and conversations with the audience on: What are affordances and challenges of learning and teaching science focusing on equity and social justice? What research do we need to move the needle closer to such a goal? What should the role of space, place, community be in grappling with teaching and learning science for equity and justice?

Strand 11: Cultural, Social, and Gender Issues

Promoting Inclusion in Culturally and Linguistically Diverse Science Classrooms

10:30 AM-12:00 PM, Salon G

Presider: Charnell Long, University of Wisconsin-Madison

"When the learning experience is fun and sometimes a challenge, that intrigues me": Affirming Science Experiences in a STEM-focused Urban High School

Noemi Waight, University at Buffalo
Jennifer Tripp, University at Buffalo
Lorenda Chisolm, University at Buffalo

ABSTRACT
This study documented the nuances of students' affirming science classroom experiences, and the nature of the classroom dynamics and environment that promoted strong science identities among high achieving ninth graders in an urban, inclusive STEM-focused high school. Data sources included teacher and student interviews, classroom observations and videos, and classroom artefacts. The findings revealed a classroom culture that promoted the objects and actions of scientific culture. This focused on the process of science, content knowledge, collaborative interactions, and a community oriented, culturally responsive and affirming science classroom. Students' experiences reflected a strong science identity; students affirmed their love for science and respected the role of their science teacher in facilitating this process. What is more, students emphasized the value of their hands-on experiences and associated these experiences as opportunities to "learn" science. This study has implications for advancing a "science for all" framework that is scientifically and culturally responsive and affirming for racial, ethnic, and linguistically diverse high achieving students.

A Critical Discourse Analysis of Disability in a Science Teacher Education Textbook: Implications for Equity
Teresa Shume, North Dakota State University

ABSTRACT
Like any curricular resource, textbooks are not, and cannot be, ideologically neutral. Conceptualizations of disability, including the medical and social models of disability, have significant implications for equity and social justice, and are an area of study within the field of Disability Studies in Education. This qualitative study used critical discourse analysis to examine the conceptualizations of disability and inclusion in a textbook designed for use in secondary science instructional methods courses in teacher education programs. Relying primarily on Fairclough's post-structurally informed approach to critical discourse analysis and drawing on Halliday's conception of Systemic Functional Linguistics, this study produced four themes, two of which are presented in this paper. Overall, the study showed that the discursive features that shape the conceptualization of disability in this textbook point towards an ideological stance congruent with the medical/deficit model of disability. Significance for equity and social justice, and implications for science teacher education are discussed.

Case Study of Physics Coursetaking, Contextual Characteristics, and Physics Achievement in Urban Schools
Martin F. Palermo, Stony Brook University
Robert Krakehl, Stony Brook University
Angela M. Kelly, Stony Brook University
Keith Sheppard, Stony Brook University

ABSTRACT
Research has shown that high school physics coursetaking has been a significant predictor of post-secondary science, technology, engineering and mathematics (STEM) study as it is regarded a foundational science and a crucial gateway course. This quasi-experimental case study explored physics access and the physics achievement of students in urban schools. Data were collected from publicly available databases on the contextual characteristics of New York State secondary schools (n=721), along with school-level physics achievement scores. Findings indicated that students in urban schools had significantly lower passing and mastery scores on standardized physics assessments when compared to students in suburban and rural schools. When examining the contextual characteristics of urban schools in a multivariable model, socioeconomic status, school size, and school-level test-taking ratio were all significant predictors of physics performance. Notably, school-level test-taking ratio partially

mediated the predictive value of socioeconomic status as related to student physics performance. This suggests that as faculty and administrators in more urban schools promote physics coursetaking, students may perform better as a group on physics standardized assessments. These findings suggest that the prioritization of physics coursetaking may promote more equitable outcomes for urban students.

R is for Resilience and Retention: The Role of Sociocultural Awareness and Affirming Attitudes towards Students

Maria S. Rivera Maulucci, Barnard College
Lisa M. McDonald, Teachers College, Columbia University
Shane Coleman, Teachers College, Columbia University

ABSTRACT
The development and nurturing of high-quality teachers is a central focus of efforts to reform STEM education. High-quality science teacher education prioritizes development of content and pedagogical knowledge, working with youth in high-need public schools, practice teaching, feedback from mentors, and a particular focus on coping skills and strategies for resilience. This paper reports on how preservice science teachers in our Noyce Program grow in sociocultural awareness, develop affirming attitudes towards students and families, and begin to take on the identity of a social justice educator, or teacher as agent of change. We provide a cross-case analysis of the four Noyce Scholars at different points on their trajectories of becoming social justice science educators: a preservice Chemistry teacher, a preservice Physics teacher, a second-year Chemistry teacher, and a fifth-year Physics teacher. Data include coursework, lesson plans, videotaped lessons, edTPA portfolios, and interviews. Analytical methods included a comparative case-study approach. The findings show that by attending to sociocultural awareness and affirming attitudes towards students across all knowledge domains of teaching, Scholars are more likely to develop coping skills and resilience to continue teaching in high-need schools.

Strand 11: Cultural, Social, and Gender Issues

Spaces of Agency: Centering teacher agency and expanding contexts for equitable science teaching and learning

10:30 AM-12:00 PM, Salon H

Discussant: Felicia Mensah, Teachers College, Columbia University

Applying Strength-Based Approaches and Re-positing Emergent Bilingual/Multilingual Learners as Epistemic Agents

Shakhnoza Kayumova, University of Massachusetts Dartmouth
Akira Harper, University of Massachusetts Dartmouth

Examining relational agency to understand teacher educators' professional growth within the individual/collective dialectic

Christina Siry, University of Luxembourg
Sara Wilmes, University of Luxembourg
Kerstin te Heesen, University of Luxembourg
Sandy Heinericy, University of Luxembourg
Nora Kneip, University of Luxembourg

Spaces of Agency for Preservice Teachers: Capitalizing on Out-of-School to Develop Culturally-Sustaining Professional Identities
April Luehmann, University of Rochester
Yang Zahng, University of Rochester
Heather Boyle, University of Rochester

Dutch-Caribbean students' formation of agentic science identities through their participation in an after-school program
Theila Smith, University of Groningen, NL
Lucy Avraamidou, University of Groningen, NL
Jennifer Adams, University of Calgary, Canada

Teacher as Bricoleur: Spaces of Agency around Resources and Informal Science Practices
Jennifer Adams, University of Calgary, Canada
LaToya Strong, The Graduate Center, City University of NY
Atasi Das, The Graduate Center, City University of NY
Susan McCullough, Queens College, CUNY

ABSTRACT
In considering teaching and learning across places and contexts in order to promote a science education for planetary well-being, we need to problematize the hegemonic ways that globalization has influenced science teaching and learning rather than allowing the "constrain[ing of] the social imaginary of science education within the limits and contradictions of capitalism." In science education neoliberal "reform" influences everything from curricular choice to classroom practice. At the global level, "big data" assesses and compares the global competitiveness of students, supporting the presumed correlation of economic advancement with educational standards. At local levels, increased emphasis on standardized education perpetuate this myth. Despite these constraints, there are spaces of agency where teachers and learners resist and counter neoliberal "reform" by enacting meaningful experiences with STEM and teacher identities are shaped by these practices. In this dialogic paper-set we have assembled a collective of international scholars who will describe the ways that educators have created spaces of agency the needs of learners are centered and authentic connections with science are fostered. Together we will discuss the role of researchers and teacher educators in fostering these spaces towards advancing the teaching and learning of STEM for the advancement of life, health and prosperity.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Nature of Engineering
10:30 AM-12:00 PM, Portland
Presider: Ryan Summers, University of North Dakota

Development of a Nature of Engineering Instrument: Results from Field Tests
Jacob Pleasants, Keene State College
Joanne K. Olson, Texas A&M University
Iliana E. De La Cruz, Texas A&M University
Kristina M. Tank, Iowa State University

ABSTRACT
The emphasis that the Next Generation Science Standards places on engineering design has created a need to deepen teachers' understanding of the nature of engineering, including what engineering is, how it works, and how it is related to science. For teacher educators and education researchers seeking to pursue this goal, a substantial need exists for instruments that can elicit teachers' thinking about the nature of engineering with reliability and validity. In this study, we present an instrument that we have developed to examine teachers' understanding of the kinds of activities that engineers do (and those that they do not). We will describe the design choices that we made in creating the instrument as well as the rationales underlying those choices. We will also present data collected during pilot phases of development as well as results from a larger field test, in which the instrument was administered to pre-service and in-service teachers across a range of educational contexts.

Engineering Professional Development with Robotics and Assessment of K-12 Teachers' Understandings of Nature of Engineering
Hasan Deniz, University of Nevada Las Vegas
Ezgi Yesilyurt, University Of Nevada, Las Vegas
Erdogan Kaya, University Of Nevada, Las Vegas

ABSTRACT
Introducing engineering at the pre-college level has gained national attention through the release of the Next Generation Science Standards (NGSS, Lead States 2013). However, pre-college engineering education research is limited compared to other similar studies in K-12 science education. In this study, we investigated the Nature of Engineering (NOE) understandings of in-service teachers and the influence of an engineering professional development program on teachers' NOE views. A total of 6 K-12 teachers participated in the study. We used the Views of Nature of Engineering (VNOE) instrument to examine teachers' NOE views. We found that our intervention was effective in improving participants' NOE views across the target NOE aspects. We believe that explicit and reflective features of our engineering professional development program contributed to substantial increases in participants' NOE views.

Science Teachers' Nature of Engineering Knowledge and Instructional Planning
Allison Antink-Meyer, Illinois State University
Anna Maria Arias, Kennesaw State University

ABSTRACT
This study investigated 30 K-8 science teachers' understanding about, and instructional planning for, the nature of engineering knowledge (NOEK). We analyzed teacher-created engineering learning cycles (ELCs), interviews, and VNOEK questionnaires after a two-year professional development program focused on teaching engineering design in science classrooms. The majority of views demonstrated at least partial understanding where the most problematic feature was the influence of optimization on engineering knowledge. These findings indicate mixed success, where the majority of views were desirable, but problematic views were found among half of all participants for at least one NOEK feature. Teachers' exit interviews suggested that they viewed teaching for NOEK understanding as important. However, their planning for learning was weak. Collectively, the ELCs and exit interviews illustrated that the teachers believed their students could, and should, engage in engineering experiences that were authentic to the nature of engineering. However, their instruction remained more reflective of the implicit strategies for teaching epistemology that have been widely criticized. The contribution of this study is its illumination of the areas of challenge and growth of K-8 science teachers

in learning about, and teaching for, understanding the nature of engineering knowledge in the science classroom context.

Strand 15: Policy

Understanding and Supporting STEM Education Improvement Efforts Within Schools and Districts

10:30 AM-12:00 PM, Eugene

Presider: Carrie D. Allen, University of North Texas

Principals as policy players: How leadership practices impact science instruction

Kathryn M. Bateman, Temple University
Scott McDonald, Pennsylvania State University

ABSTRACT

Science teachers exist within a large educational system which includes many actors at many levels from the US Department of Education through building-level principals. In this ethnographic study, we examine the influence of the building level principal to determine how the principal influenced science teachers' level of productive policy play. The role of the administrator in a science teacher's productive policy play was found to be based on the administrator's espoused practices, understanding of science education, and relationship with the teacher. Administrators espoused practices informed the policies that they made in their building; however, as principals had minimal knowledge of science education practices. Productive policy play for science education was constrained as administrative espoused practices, and thus local policies did not include science education practices explicitly. Furthermore, a teacher's level of productive policy play was influenced by their relationship with their principals – productive policy play increased when there was a collaborative relationship, and reduced in a managerial one. These findings indicate a need to examine the relationship between policymakers, administrators, and science education researchers, as well as the educational opportunities afforded to school district leadership around science education.

An emerging model of instructional change teams

Ntiana (Diana) Sachmpazidi, Western Michigan University
Alice Olmstead, Texas State University
Charles R. Henderson, Western Michigan University
Andrea Beach, Western Michigan University

ABSTRACT

Academic programs and departments are increasingly forming teams to improve undergraduate STEM instruction, but research guiding this process is limited. Prior work suggests that such efforts could be highly successful in producing more innovative, high quality, and sustained improvements than instructors working alone. On the other hand, team-based efforts also involve a higher risk of failure. We are pursuing an exploratory study of teams that are working to revising existing courses at institutions across the U.S. For this paper, we conducted individual interviews with multiple team members across six teams to elicit team members' perspectives on their collaboration. Using a grounded theory approach, we identified emerging themes in the interview data and expanded our previously developed model of instructional change teams. We find five team-level processes that shape how these teams work together: strategic leadership, egalitarian power dynamics, team member commitment, effective communication, and clear decision-making processes. We also identify three important

cognitive/affective emergent states---shared vision, psychological safety, team cohesion---that are influenced by the team processes. In this paper, we focus on one exemplary team within our dataset to illustrate how these processes and states arose in our dataset and provide a useful example for practitioners.

Making Sense of Reform: Hybridizing Local and Ideal Instructional Practices

William E. Lindsay, University of Colorado Boulder

ABSTRACT

The tendency for practitioners to make modifications to reform efforts is well-documented; however, research on the implementation of reform-based instructional practices is often quick to criticize these modifications as appropriations, unresolved issues, or misunderstandings. This paper attempts to disrupt this tendency by reconceptualizing teacher modifications to reform efforts as productive organizational sensemaking. Using ethnographic data collected during a 32-month Research Practice Partnership (RPP) with a no-excuses charter network, I identify the emergence of hybridized teaching practices that contained components of instruction aligned with the Next Generation Science Standards and with the no-excuses pedagogy previously used by the network. I then demonstrate how these hybridizations helped teachers make sense of reform efforts in a manner coherent with their organizational context, which contributed to tangible and sustained instructional change. These findings suggest that RPPs are promising sites for productive organizational sensemaking and the development of hybridized teaching practices, especially for educational organizations whose normative instructional practices are far removed from the ideals of reformers.

Science Professional Development and Barriers to Elementary Science Education in a High Need School Districtt

Kathleen D. Johnson, Boston University
Peter S. Garik, Boston University
Bruce Anderson, Boston University
Donald DeRosa, Boston University
Caleb Farny, Boston University
Melissa Kaufman, Boston University
Evangeline Stefanakis, Boston University

ABSTRACT

There is an acknowledged need to improve the science education in the United States. The Next Generation Science Standards call for ambitious outcomes for students in these grades. At the same time, it is well established that elementary teachers in high need districts are often underprepared in their content knowledge and under-resourced to teach to these standards. Moreover, the time allotted to science instruction is often less than 2 hours per week resulting in poor progress by children coming from economically disadvantaged homes. For the past four years, our team of science educators and scientists have provided summer professional development workshops and extended support during the school year for teachers in multiple schools in a high need district. We are investigating the barriers that teachers face to introducing project based learning, and the barriers our team encounters in our efforts to support the teachers.

Concurrent Session 5
1:45 PM-3:15 PM

Publications Advisory Committee
Admin Symposium-Publishing, Reviewing and Writing for the Journal of Research in Science Teaching: Lessons Learned and New Visions
1:45 PM-3:15 PM, Mt Hood

Publishing, Reviewing and Writing for the Journal of Research in Science Teaching: Lessons Learned and New Visions
Fouad Abd-El-Khalick, University Of North Carolina At Chapel Hill
Dana L. Zeidler, University Of South Florida
Troy Sadler, University of North Carolina at Chapel Hill
Felicia Moore-Mensah, Teachers College, Columbia University
Elizabeth C. Niswander, University Of Illinois At Urbana–Champaign

ABSTRACT
The Journal of Research in Science Teaching is the official journal of NARST: A worldwide organization for improving science teaching and learning 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 the editors for JRST over the last five years, Drs.Fouad Abd-El-Khalick and Dana Zeidler will present how our vision of the journal has impacted the work represented in JRST, as well as lessons learned over these years. This session will also introduce the newly appointed in-coming editors – Drs. Troy Sadler and Felicia Moore-Mensah, who will provide their visions for how the journal will build on the past successes of generations of JRST, and describe new visions for the continuation of its robust future.

Strand 1: Science Learning, Understanding and Conceptual Change
Modeling
1:45 PM-3:15 PM, Salmon
Presider: Cesar Delgado, North Carolina State University

Fostering Students' Understanding of Iconic Model Comprehension
Veronika Bille, University of Duisburg Essen
Maria Opfermann, Ruhr-Universität Bochum
Julian Roelle, Ruhr-Universität Bochum
Stefan Rumann, University Of Duisburg-Essen

ABSTRACT
Studying chemistry at university can be challenging and requires certain prerequisites on side of the students, one of which appears to be “visual model comprehension”. Our study investigated whether study performance in chemistry can be increased by training visual model comprehension, in particular with regard to iconic visual models, which refer to structural depictions that show similarities to reference objects (e.g., visual displays of atomic orbitals). To do so, we used a worked-examples approach that aimed at supporting deeper comprehension of the structure of matter. An experiment

using an intervention and a control group and a pre-post-follow-up design showed that over the course of one semester, the training can increase visual model comprehension, which goes along with an increase in domain-specific content knowledge.

How Modeling can Help Students Condense Meaning Within Language

Daniel K. Capps, University of Georgia
Jonathan Shemwell, The University of Alabama
Ayca K. Fackler, The University of Georgia
Carlson H. Coogler, The University of Alabama
Hong T. Tran, The University of Georgia

ABSTRACT

The theory of modeling instruction explains very well how modeling can help students develop meanings about phenomena. Less well explained is how modeling can help learners condense such meanings within efficient linguistic forms. To shed light on this process, we present a detailed case of a ninth grade student dyad consensing meaning while modeling energy transfer in cellular respiration. The case revealed two phases of condensation. In the initial, proto phase, condensable meaning was developed but remained dispersed across the sources from which the model would eventually be developed. The second was the condensation phase, wherein these meanings were unified in a depictive representation tied to short- and long-form linguistic representations. Analysis of the case shows a crucial role of a modeling task directive to seek unified meanings across phenomena. Also brought to light is the utility of elaborating meaning by working through transformations between models and the sources upon which they are based.

Identifying Large Scale Scientific Modeling Practices That Can Organize Scaffolding Strategies for Whole Class Discussions

Maria Cecilia Nunez-Oviedo, University of Conception
John J. Clement, University of Massachusetts

ABSTRACT

Recently there has been increased emphasis on learning explanatory models as a key to conceptual understanding. However, science teachers can experience many tensions while leading modeling discussions. Here we use the results of a case study of an experienced teacher leading modeling discussions of three middle school life sciences classes to examine how to mitigate these tensions. A qualitative microanalysis of the videotaped whole class discussions led to the identification of a variety of modeling processes operating at two different time scale levels. All of these processes are similar to those found in recent studies of practices of expert scientists. Implications from the case study suggest that: (1) A teacher need not be limited to the two opposing interaction styles of Open Discussion vs. Authoritative lecture. (2) It is possible to start from student-generated models that conflict with the target model and still arrive at the target model for a lesson through discussion. (3) It is possible for a teacher to foster student modeling practices at the same time that they are teaching science content, by scaffolding the two levels of model construction processes identified. Thus the framework of processes may provide a way to organize such scaffolding strategies.

The Affordances of Integrating Crosscutting Concepts and Modeling: Improving Science Learning With a Connective Structure

Ayca K. Fackler, The University of Georgia
Carlson H. Coogler, The University of Alabama

Daniel K. Capps, The University of Georgia
Jonathan Shemwell, The University of Alabama
Hong T. Tran, The University of Georgia

ABSTRACT
The Framework for K-12 Science Education sets an ambitious vision for teaching crosscutting concepts by emphasizing that they provide students with a “connective structure” that helps them understand science ideas. Little research has explored how this occurs. This empirical investigation aims to show how modeling the crosscutting concept of energy supports the development of a connective structure that bolsters students’ learning about cellular respiration. The findings reveal that using modeling to develop the connective structure for energy enhances both the quantity and the quality of scientific text processing. This research suggests two implications: (1) providing a connective structure that aids students’ use of crosscutting concepts like energy in processing science text and learning, and (2) that modeling provides an effective avenue for developing this connective structure.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Moves in Teaching & Discourse
1:45 PM-3:15 PM, Hawthorne/Belmont/Laurelhurst
Presider: Luiz Gustavo Franco Silveira, Universidade Federal de Minas Gerais

Gender, Power, and Positioning: Examining Discourse in Middle School Students' Small Group Engineering Interactions
Jeanna R. Wieselmann, Southern Methodist University
Khomson Keratithamkul, University of Minnesota
Emily A. Dare, Florida International University
Elizabeth A. Ring-Whalen, St. Catherine University
Gillian H. Roehrig, University of Minnesota

ABSTRACT
Small group activities are ubiquitous in middle school STEM and engineering instruction; however, student participation in small group activities is often inequitable. With extensive research demonstrating differences in students’ roles within small groups, this study uses discourse analysis methods to explore small group dynamics and determine how gender relates to students’ power as they participate in small group engineering activities. This study focuses on a small group of four students (two girls and two boys) in the sixth grade who were designing a laser security system using their knowledge of reflection and refraction. Key exchanges were transcribed and coded to capture students’ positioning of themselves and others as participants in the small group engineering design activity. Findings suggest that the two boys in the group were positioned as less integral to the group’s success, both by themselves and by the girls. Once the precedent of the girls working independently of the boys without their input was established, this power dynamic proved difficult to disrupt, even when the boys made moves to equalize power. Findings from this study highlight the significance of prior participation in shaping students’ abilities to access power within small group engineering activities.

Characterizing the Teaching Moves of Engineering Outreach Ambassadors

Karen Miel, Tufts University
Elizabeth Moison, Tufts University
Merredith D. Portsmore, Tufts University
Kelli Paul, Indiana University
Euisuk Sung, Indiana University
Adam V. Maltese, Indiana University

ABSTRACT
University-led engineering outreach programs are significant providers of pre-college engineering education. Often, these outreach efforts are facilitated by university students, or engineering ambassadors, who are typically disciplinary specialists and novice educators. While research has characterized the effective teaching moves of experienced classroom teachers, the nature of engineering ambassadors' moves and their influence on student learning are less well understood. This study asks What are the teaching moves of engineering ambassadors that support engineering design practice? This case study characterizes the teaching moves of two ambassadors interacting with a trio of elementary students during a four-session engineering design challenge and connects these interactions to students' engagement in engineering practices. Thematic analysis suggests ambassadors support students' engineering engagement through scaffolding reflective decision-making. This work expands understanding of the affordances of engineering ambassadors in classrooms and deepens understanding of teaching moves and the influences of these moves on students.

Tracing Links Between Teacher Moves, Student Framing, And Student Learning In A Middle School Classroom

Sherry A. Southerland, Florida State University
Jennifer Schellinger, FSU
Lama Jaber, Florida State University
Harini Krishnan, Florida State University

ABSTRACT
The research presented here explores the epistemological framing dynamics in one middle school science classroom, tracing how the teacher's moves influenced the students' framing of their work, and the ways in which that framing influenced student learning. Data sources included classroom videos of three multi-day lessons (Cell Characteristics, Cell Division, and Natural and Sexual Selection), teacher and student work products, and a series of open-ended and structured stimulated recall interviews with the teacher and students. Our analysis reveals that while the teacher framed small group argumentation activities as spaces for students to generate and negotiate ideas, brief but influential moves at the end of the lesson, which consistently emphasized the correct answer, served to undermine students' sensemaking and the role of evidence in creating explanations. These instructional moves, while only occupying a small amount of instructional time, taught students not to seek the strongest explanation from a group of possibilities, but rather to wait for the correct explanation to be revealed from an authority.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Elementary Science Instruction in the US: Warning Signs and Ways Forward

1:45 PM-3:15 PM, Meadow Lark/Douglas Fir - 3rd floor

Trends in Elementary Science Instruction From 2012 to 2018
Eric R. Banilower, Horizon Research, Inc.

Novice Elementary Science Teachers
Peggy J. Trygstad, Horizon Research, Inc.

Factors that Predict the Extent to Which Elementary Teachers' Engage Students in the Science Practices
Laura M. Craven, Horizon Research, Inc

Differences Between Self-Contained and Non-Self-Contained Elementary Science Classes
Patrick S. Smith, Horizon Research, Inc.

ABSTRACT
This related paper set reports data from a national survey of K-12 science education in 2018. The first paper presents trends using data from a similar 2012 study, conducted just before release of the NGSS. On many indicators, the status of elementary science instruction has declined. Among other warning signs, elementary teachers are now less likely to feel prepared for science instruction, in terms of both content and pedagogy. The second paper focuses on novice teachers, comparing them to veterans and identifying the unique challenges novices face. It also describes common types of induction programs and suggests ways they can be used to help novices. The third paper reports results of a path analysis designed to identify factors that predict the prevalence of effective instructional practices, including an emphasis on science and engineering practices. The final paper explores differences between science instruction that occurs in self-contained and non-self-contained settings (i.e., teachers specializing in science as opposed to teaching all core subjects). Among the most important differences, non-self-contained classes spend twice as much time per day on science as self-contained classes. Other differences suggest the non-self-contained arrangement holds promise for addressing several challenges associated with elementary science instruction.

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

Teaching for Science Literacy at Scale

1:45 PM-3:15 PM, Salon E
Discussant: Joseph Krajcik, Michigan State University
Presider: Charles W. Anderson, Michigan State University

Designing Curriculum to Support the Literacy Aspects of Science Literacy
Kirsten D. Edwards, Michigan State University
Charles W. Anderson, Michigan State University

Utilizing Three-Dimensional Science Learning and Situated Instruction to Increase the Adoption of Sustainable Knowledge and Practice Among Rural Agriscience Students
Craig Kohn, Michigan State University

Factors affecting students' learning about [name of project]
Qinyun Lin, Michigan State University
Ken Frank, Michigan State University
Charles W Anderson, Michigan State University

Classroom Discourse and Its Connections to Student Learning
Beth A Covitt, University of Montana
Christie Morrison Thomas, Michigan State University
Qinyun Lin, Michigan State University
Elizabeth X de los Santos, University of Nevada Reno
Charles W Anderson, Michigan State University

Teacher Orientations and Contexts: Making Connections to Classroom Discourse and Student Learning
Christie Morrison Thomas, Michigan State University
Qinyun Lin, Michigan State University
Stefanie Marshall, University of Minnesota
J. Brian Hancock, Alma College
Elizabeth Tompkins, Michigan State University
Charles W Anderson, Michigan State University

ABSTRACT
The papers in this session report data from a design-based implementation research project teaching carbon cycling at multiple scales at the middle- and high-school level. This large-scale project involved 145 teachers and over 25,000 students over four years of data collection. Data include a total of 197,000 student assessments, 881 teacher surveys, plus interviews with teachers, classroom video, examples of student work, and interviews with students in case-study classrooms. The papers use samples from this data set to address three design challenges. The first challenge, addressed in Papers 1 and 2, focuses on environmental science literacy as a goal, preparing all students to make informed citizenship and lifestyle choices. The second challenge, addressed in all five papers, focuses on enacting an instructional model that combines investigations and cognitive apprenticeship-based instructional approaches. The final challenge, addressed in Papers 3, 4, and 5, focuses on a core issue of implementation at scale, sometimes summarized as “breadth vs. depth.” Our work with a diverse group of science teachers provides us with insights about why some teachers continue to opt for faster-paced content coverage over in-depth mastery of scientific practices, as well as the consequences of these choices for students’ three-dimensional learning.

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

Teacher learning, efficacy and practice

1:45 PM-3:15 PM, Salon D
Presider: Kathryn Green, University of Georgia

Learning Against All Odds: A Case Study of an Out-of-Field Science Teacher in a Small Rural School
Harleen Singh, University of Georgia
Elana B. Worth, University of Georgia
Julie A. Luft, University of Georgia

ABSTRACT
Out-of-field (OOF) teaching occurs when there is a mismatch between the subjects that teachers are assigned to teach and their qualification and certification (ingersoll, 1998). While we know that OOF teaching is prevalent in secondary schools (NCES, 2017), little is known how OOF teaching looks like in

the classroom. This qualitative case study explores in-depth how a beginning, uncertified, OOF teacher of science built his self-efficacy and learnt to use reform-based teaching practices. The teacher was in his first year of teaching, placed in a high poverty, small, rural school in the US. The teacher's self-efficacy was determined through classroom observations, and interviews with the teacher, head of the science department, and the school principal. The use of practices was explored in reference to the Next Generation of Science Standards (NGSS) (Lead States, 2013). The findings from the study indicate how a strong support system in the school helped the teacher develop high levels of self-efficacy. In spite of his self-efficacy, he gave his students limited experiences with the use of reform based practices, as he struggled to master content, pedagogy, and practices at the same time. This study has implications for pre-service teacher education and in-service support programs.

Finding one's professional self: Navigating teacher identity in the figured worlds of schools

Gail Richmond, Michigan State University
Kraig A. Wray, Michigan State University

ABSTRACT

External factors exert "pushes and pulls" on teachers which move them to use or avoid using reform-oriented instructional strategies. Internal factors such as professional identity and agency also are at play. We propose that challenges that beginning teachers in particular face can be addressed more effectively if we understood these pushes and pulls on beginning teachers; how they perceive and react to elements of the worlds they inhabit; and how these shape actions they take relative to their place in the world as they understand it. Using a Figured World lens, we asked: In what ways are novice teachers' identities influenced by their school? Which factors of a school world help define a teachers' professional identity? What actions do novice teachers enact in response to their school world? We used inductive case-based methodology, modified inductive constant-comparative method, and analytical memo writing to analyze journals, multiple interviews and teaching plans. Analysis revealed that three of the FW elements and decisions by the beginning teachers about actions which will maximize their feelings of agency contribute significantly to their professional identity. The significance of these findings and of the theoretical framework for the design of preparation and induction programs will be discussed.

Teachers' Pre-emptive Instructional Adjustments Based on Awareness of Student Ideas Highlighted in a Learning Progression

Julia Christensen, Michigan State University
Alicia Alonzo, Michigan State University

ABSTRACT

Teachers make instructional adjustments on a regular basis. These adjustment decisions are complex in nature and often mediated by a number of different teacher intentions. Learning progressions (LPs), or descriptions of the successively more sophisticated ways of thinking about a topic that can follow one another as children learn, have the potential to help teachers navigate these decisions. Therefore, this study asked: 1) In what ways did the awareness of student ideas highlighted in a LP prompt two teachers to preemptively make instructional adjustments as they planned together?, and 2) What teacher intentions might be mediating this process, including any related to the LP-based professional development the teachers received? This is a unique case study of two teachers working together to preemptively respond to student ideas. Findings show that teachers most commonly made instructional adjustments by modifying examples and teacher language used with students and adjusting their expected outcomes for students. Additionally, the two most common intentions were to not foster

"misconceptions" and to not jump students straight to the top of the LP. The interaction of these intentions and instructional adjustments are productive first steps toward the development and use of LP-based curricular materials.

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

Student metacognition and systems thinking

1:45 PM-3:15 PM, Salon C

Presider: FangFang Zhao, University of Minnesota

Impacts of Inquiry-based Teaching on Undergraduate Students' Contextualized Problem-solving through the Lens of Systems Thinking

Ya-Chun Chen, National Sun Yat-sen University; Australian Catholic University
Zuway-R Hong, National Sun Yat-sen University; Australian Catholic University
Huann-Shyang Lin, Australian Catholic University; National Sun Yat-sen University

ABSTRACT

This study explores the effect of integrating inquiry-based activities into teaching on undergraduate students' systems thinking ability when they are involved in contextualized problem-solving. The intervention of inquiry-based activities was used for the experimental group (n=70) while the comparison group is composed of 83 students without using the inquiry-based teaching intervention. The instrument of the study is contextualized problem solving (CPS) assessment instrument which contains three open-ended questions about the application of gas law. The results show that the experimental group significantly outperforms the comparison group in the systems thinking total score and the three characteristics of retrieving essential science concepts, organising the relationships among science concepts and subsystems, and identifying hidden dimensions and limitation of a whole system and making generalisation. In addition, the experimental group makes significant progress in the overall performance of systems thinking.

Socio-Hydrologic Systems Thinking: An Analysis of Undergraduate Students' Operationalization and Modeling of Coupled Human-Water Systems

Diane Lally, University of Nebraska-Lincoln
Cory T. Forbes, University Of Nebraska–Lincoln

ABSTRACT

Learning to think about the interactions and the dynamic nature of systems are critical outcomes of science learning. However, students need support to develop systems thinking skills in undergraduate geoscience classrooms. While systems thinking-focused instruction has the potential to benefit student learning, gaps exist in our understanding of undergraduate students' Earth systems thinking, particularly their metacognitive evaluation. To address this need, we have designed, implemented, refined, and studied an introductory-level, interdisciplinary course focused on coupled human-water, or socio-hydrologic, systems. Data includes student models and explanations of a socio-hydrologic issue from three semesters (n=129). Written responses were analyzed using an operationalization rubric while the diagrammatic model features were counted. Analyses of the written explanations suggest students were best able to operationalize their systems thinking about problem identification (M=2.22 SD=0.73) as compared to unintended consequences (M=1.43, SD=1.10). Diagrammatic systems thinking models focused most strongly on system components (M=13.5, SD=7.15) as compared to mechanisms or overall phenomenon/patterns. Qualitative analysis of model limitations revealed themes of scope/scale

limitations, temporal limitations, and specific components, mechanisms, or phenomena excluded from the model. These findings have implications for supporting systems thinking in undergraduate geoscience classrooms, as well as insight into links between these two skills.

Supporting student generalizable metacognitive frameworks for STEM learning

Regina Barber DeGraaff, Western Washington University
Gabriel Critquit-Matos, Western Washington University
Thanh K Le, Western Washington University

ABSTRACT

In the present study, we explore undergraduate science students' frameworks for metacognition. The study focuses on student understanding of their metacognition as a general framework for science learning which includes both cognitive and sociocultural factors that may impact learning. Often within undergraduate science courses, students' metacognition is geared towards content understanding. However, their metacognitive processes can be generalized beyond the content to sociocultural aspects of learning science. Students can reflect on how and why their social interactions within the science community may impede or support their own or others' participation. This type of inclusive metacognition, as well as metacognition targeted towards their content understanding, has the potential to support equity and inclusion in science. We conducted small focus groups with 10 undergraduate science majors. Participants were enrolled in first-year seminars focused on providing explicit metacognitive frameworks (i.e., instruction on the concept of metacognition and on research-based learning strategies) and part of an inclusion program aimed to increase the number of under-represented students in the sciences. We describe undergraduate science majors' metacognitive frameworks and in what ways they extend their frameworks to equity.

Perceptions of STEM Students and Alumni on Developing 21st Century Skills

Judy Yehudit Dori, Technion- Israeli Institute Of Technology
Rea Lavi, Technion- Israeli Institute Of Technology
Marina Tal, Technion- Israeli Institute Of Technology

ABSTRACT

The current era exhibits an increasing need for a new set of skills, often 21st century skills. However, studies have found that students in science, technology, engineering, and mathematics (STEM) higher education may be underprepared for what present-day STEM professions require. We developed an online questionnaire to assess the perceptions of alumni and students (N = 1,578) regarding the development of their 21st century skills during their studies at a top tier STEM higher education institute. Graduate degree alumni and graduate students scored significantly higher for some of those skills—especially soft skills—compared with undergraduate degree alumni and undergraduate students, respectively. Three teaching and learning methods were found to develop the largest number of skills and to dominate the development of soft skills: course assignment, project, and research. These results echo previous findings, that active learning methods centered around collaboration and authentic problems are particularly useful for developing 21st century skills. Our study is unique in that it provides a detailed account of how students and alumni, as well as undergraduates and graduates in a wide range of STEM higher education subjects, perceive the extent to which various teaching and learning methods have developed their 21st century skills.

Strand 6: Science Learning in Informal Contexts

Informal science in afterschool programs

1:45 PM-3:15 PM, Salon F

Presider: Ying-Ting Chiu, The Ohio State University

Authentic STEM research, practices of science, and interest development in an informal science education program

Bobby Habig, American Museum of Natural History; Queens College, City University of New York
Preeti Gupta, American Museum Of Natural History

ABSTRACT

Two critical challenges in science education are how to engage students in the practices of science and how to develop students' interest. The goal of this study was to test whether participation in a museum-based informal science education (ISE) program where youth engage in the practices of science via authentic research helps participants to learn the skills and practices of science and in turn bolsters interest in scientific research. To accomplish our goal, we apply Hidi and Renninger's well-tested theoretical framework for studying interest development. Specifically, we ask: As youth engage in authentic science research, do they develop competence in mastering the skills and practices of science? Do participants increase, maintain, or decrease interest in science research as a result of this experience? Why do some participants increase, maintain, or decrease their interest in science research during this informal learning experience and what implications do these findings have on program design? Our findings suggest that participation in authentic research in an ISE context affords youth critical opportunities for gaining mastery of the skills and practices of science, which in turn reinforces, and in some cases increases participants' interest in scientific research beyond the span of the program.

Burmese Youths' Enactment of Critical STEM Literacy Practices in an Afterschool Program

Minjung Ryu, Purdue University
Shannon M Daniel, Vanderbilt University
Mavreen Rose S. Tuvilla, Purdue University
Casey E Wright, Purdue University

ABSTRACT

With an increasing number of refugees who resettled in the United States, research to examine and support resettled refugee youth's learning of STEM disciplines becomes a high priority. In response to this need, we designd and implemented a commynity-based afterschool STEM program for resettled Burmese high school youth to engage them in critical STEM literacy practices in the area of climage change education. Drawing on the ideas of critical literacy (Luke, 2012) and critical science literacy (Basu, Calabrese Barton, & Tan, 2011), we define critical STEM literacy as the dialogic reading and composition of STEM ideas that can transform STEM discourses and practices, individuals, local communities around us, and global societies in order to improve democracy and justice. We analyzed videorecordings of the afterschool program sessions to understand how the teens engaged in critical STEM literacy practices within an urban refugee youth program. Our analysis showed that the teens engaged in critical STEM literacy in four different ways. In the presentation, we will share these four themes with examples from the program and discuss implications for science education in linguistically, racially, and culturally diverse learning contexts.

Investigating Productive Science Engagement in an Afterschool Science Program for Resettled Burmese Refugee Youth

Mavreen Rose S. Tuvilla, Purdue University
Minjung Ryu, Purdue University
Casey E Wright, Purdue University
Shannon M Daniel, Vanderbilt University

ABSTRACT

Research studies indicate that learners show differences in engagement depending on the learning context. Informal settings such as afterschool programs provide traditionally minoritized learners to participate more, take more risks, and develop productive science identities. This paper investigates how science engagement is productively fostered in a community-based afterschool science program designed for resettled Burmese refugee youth. We adapt Nasir and Cooks' (2009) framework of material, relational, and ideational resources to analyze how refugee youth utilize these resources in the afterschool setting. Using ethnographic data collected from our year-long implementation, we employed multimodal transcription techniques to look at youths' interactions closely and gain insights on youths' unique utilization of material, relational, and ideational resources. Multimodal transcription is a way of transcribing that accounts for language, gaze, body posture, gesture, use of images, proxemics and all other modes that constitute a communicative activity. The insights we gain from the afterschool context could possibly be translated to formal school settings and can be leveraged to promote productive science learning.

Student Use of Evidence in Constructing Socioscientific Arguments in an Elementary After School Program

Melissa M. Cieto, University of Massachusetts Dartmouth
Stephen B. Witzig, University Of Massachusetts Dartmouth

ABSTRACT

Adopting the Common Core State Standards (CCSS) (NGA & CCSSO, 2010) and Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) has led to revising elementary school science curriculum (NRC, 2012). New iterations of curriculum focus on argumentation from evidence. The National Research Council (NRC) has developed expectations for all science students including goals that can be achieved through student-driven inquiry, rigorous discussion, and direct application of science to students' lives (NRC, 2012). One means of accomplishing these goals is by teaching science through a socioscientific issue-based approach (SSI). This qualitative study was guided using case study methodology to address the over-arching research question: How might fifth grade students in an elementary after-school program make use of scientific evidence to construct socioscientific arguments? We posit the following three assertions: 1) Elementary students rely on multimedia resources to warrant arguments; 2) Students reference personal interests as evidence in SSI argumentation; and, 3) Elementary students may benefit from scaffolding to discern the main idea of sources when independently researching SSIs. We discuss the implications of the findings and provide suggestions for future research in this area to continue the dialogue about teaching science through an SSI based approach at the elementary level.

Strand 7: Pre-service Science Teacher Education

English Learners and Literacy Integration

1:45 PM-3:15 PM, Salon A

Presider: Xiaoxin Lyu, Teachers College Columbia University

The Impact of a Teacher Preparation Intervention on Secondary Preservice Teachers Beliefs Toward Teaching Science to English Learners with Language and Literacy Integration

Edward G. Lyon, Sonoma State University

ABSTRACT

We report on the results from a pre and post survey administered to pre-service secondary science teachers who had participated in a teacher preparation intervention (n=120) that involved restructuring secondary science method courses across 4 universities to better address how to support English Learners through the integration of science learning and language/literacy development. Changes from pre to survey were compared to a baseline control group (n=76) who participated in the respective programs the year before restructuring. The survey, with sound psychometric properties, revealed that (1) responses from the baseline control group did not differ significantly on the pre-survey from the treatment groups, (2) changes from pre to post were positive (and significant) in the treatment group, (3) there was a significant difference in the change between treatment and control, and (4) there was significant change across all 4 programs (albeit with variation in the pre and post responses). The results provide once form of evidence for impact of the intervention, which is significant as we come to understand innovative approaches to preparing novice secondary science teachers to teach ELs in ways that resonate with reformed based science, such as through Next Generation Science Standards.

Promoting the Discourse of English Learners During the Enactment of Cognitively Demanding Work

Walter Aminger, University Of California, Santa Barbara

ABSTRACT

Students designated as English learners (ELs) are the fastest growing group of students in K-12 public schools across the United States (NGSS Lead States, 2013). This study sought to understand how preservice science teachers can contribute to educational equity by ensuring that all students, including EL students, have substantive opportunities to engage in rigorous content learning as they are supported to use scientific discourse. We found that our participants were willing to take responsibility for supporting the academic language demands of the cognitively demanding tasks they implemented, and that they were able to draw on a robust range of strategies. While such attention to language is both understandable and important, our principle-based framework argues that teachers must do more. As such, our findings suggest that teacher education programs must carefully attend to the balance between supporting academic language and supporting rigorous content learning for ELs. Finally, our study also suggests that if secondary science teachers are expected to help their students successfully engage in scientific discourse, teacher education programs will need to provide preservice teachers with an even deeper understanding of how to scaffold the complex linguistic demands of discourse.

Learning to Integrate Science-Specific Literacy in Science Teaching: A Study of Elementary Preservice Teachers

Regina P. McCurdy, University of Central Florida
Su Gao, University of Central Florida
Vassiliki ("Vicky") I Zygouris-Coe, University of Central Florida
Katherine Cruz-Dieter, University of Central Florida
Rebeca A Grysko, University of Central Florida

ABSTRACT
Next Generation Science Standard expects teachers to teach science content by engaging students in science and engineering practices. To help teachers of science meet these demands, teacher educators should prepare preservice teachers (PSTs) to develop knowledge of science and literacy to better facilitate the science learning of all students. However, elementary science PSTs usually take literacy methods courses disconnected from science methods courses. Consequently, they are usually not prepared to differentiate between general literacy and science-specific literacy (SSL) instruction or how to integrate literacy into science teaching and learning. It is important to provide support for PSTs and instruction in understanding what SSL is and how to use it in supporting students' science and literacy learning in tandem. The purpose of this study was to explore 1) whether twenty PSTs, enrolled in a science teaching methods course, changed in their understanding of SSL evidenced in their reflective responses to an initial belief paper and final paper, and 2) how these PSTs implemented SSL instruction in lesson planning. PSTs' understanding of SSL notably developed from their belief paper to final paper responses. PSTs' group lesson plans implemented knowledge about how SSL can be utilized to develop students' science learning.

Strand 7: Pre-service Science Teacher Education
Science Education and Cultural Access
1:45 PM-3:15 PM, Salon B
Presider: Pamela S. Lottero-Perdue, Towson University

Supporting Pre-Service Community Teachers in Implementing Culturally Responsive PBL

Imelda L. Nava, UCLA
Jaime Park, UCLA Center X

ABSTRACT
Pre-service urban STEM teachers engaged in community centered PBL. The community teacher and deep learning frames support the work of C-STEM-PBL. 31 pre-service math and science teachers engaged in the enactment of C- STEM-PBL. Over 80% were able to contextualize the content and relate it to real life, making tasks authentic and deep learning experiences. 41% constructed a PBL driving question situated in the community. Family engagement primarily involved presenting to family and community as well as accessing their feedback. Pre-service teachers were challenged by time and logistical constraints; however, 90% of pre-service teachers implemented the projects in their field placements. Overall, this was a community focused deeper learning experience with implications for supporting community centered STEM teachers.

Issues in Preparing American Indian STEM Teachers
Regina C. Sievert, Salish Kootenai College/National Science Foundation
Joan LaFrance, Mekinak Consulting

ABSTRACT
American Indians are among the most severely underrepresented people in STEM professions in the United States. The fraction of American Indians teaching STEM in US schools at the secondary and post-secondary levels is negligible, while the student Native student population exceeds 1% of the US student population. Increasing the number of American Indian STEM educators is widely believed to be an important strategy for improving STEM outcomes for American Indian people. Though many have been initiated in the US over the last 40 years, efforts to sustain programs that graduate significant numbers of American Indian STEM teachers have seen limited success. Through literature review and interviews with stakeholders, this qualitative study identified elements of successful teacher preparation programs for American Indian STEM teachers. Challenges for maintaining such programs were also identified. Interviewees included American Indian STEM in-service and preservice teachers, education and STEM faculty and administrators at tribal and mainstream colleges, and administrators at secondary schools with high American Indian enrollment. A variety of specific themes emerged during analysis; a significant fraction relates to the cultural congruence between students' cultures, STEM instruction, and academic settings. Implications for teacher preparation programs and recommendations for future research will be presented.

Elementary Science Preservice Teachers' Perceptions of the Interactions of Science and Culture
Jordan L Henley, University of Georgia
Dorothy Y White, University of Georgia
Phaidra Buchanan, University of Georgia
Julie M. Kittleson, University Of Georgia

ABSTRACT
Science teacher educators (STEs) are responsible for assisting pre-service teachers (PSTs) in recognizing inequities in the classroom and developing the skills needed to assist their students from all cultures in learning. The first step in addressing this responsibility is for PSTs to be made aware of the influence of culture on science and science education. The Cultural Awareness in Mathematics and Science Unit Project (CAMS Up!) is designed to develop PSTs' cultural awareness within the context of teaching and learning science. This study focuses on elementary PSTs' perceptions about culture, science-specific beliefs about culture, and beliefs about teaching science to students of varying cultures throughout CAMS Up!. The study is grounded in culturalizing science instruction and critical reflection frameworks and seeks to understand PSTs' beliefs in order to better understand how to prepare them to teach science equitably. Themes in the data include PSTs' experiences being othered, becoming aware of their bias and the influence of culture on instruction, and PSTs' visions for inclusive science classrooms. The session will also present topics the PSTs found controversial and how they avoided discussing them. Implications for elementary science methods courses will be discussed.

Strand 8: In-service Science Teacher Education
Teacher Identity
1:45 PM-3:15 PM, Pearl
Presider: Sage Andersen, University Of California - Irvine

Dialogic Investigation of Science Teacher Identity Development: The Case of 3 Career Changers
Lara Smetana, Loyola University Chicago
Ali Kushki, Loyola University Chicago

ABSTRACT
This qualitative study explores the complexity of novice science teachers' professional identity development, specifically focusing on cases of three individuals who entered teaching after making a career change. Adopting Akkerman and Meijer's (2011) dialogic approach to conceptualizing teacher identity development over time, the study combines post-modern views of identity most frequently seen within recent science education literature with complimentary modern views. The cases investigate science teacher identity as unitary and multiple, continuous and discontinuous, individual and social. Across the three cases, experiences of disequilibrium due to I-position conflicts were found to be important growth opportunities. Analysis indicated that part of overcoming challenges was realizing the value of embracing, rather than trying to suppress, their varied I-positions and experiences from previous careers. This study adds to the growing body of literature on science teacher idenity and science career changers.

Middle Grade STEM Teachers' Conceptions and Prioritization of Core Instructional Practices Over Time
Matthew Kloser, University Of Notre Dame
Matthew Wilsey, Stanford University

ABSTRACT
Research on core instructional practices has generally focused on pre-service teacher education. With the advancement of frameworks like Ambitious Science Teaching (Windschitl et al., 2012), a practice-based approach to teaching and learning science is becoming more prevalent among novices. However, once novices enter the classroom, they may have difficulty collaborating with more veteran teachers who either have different lenses for viewing teaching, different priorities for what counts as high-quality instruction, or different vocabulary, thus creating barriers to shared understanding and collective growth. This study explores a group of 131 in-service middle school science and math teachers' (minimum experience is three years) conceptions and priorities of what aspects of teaching are most impactful for positive student outcomes. Findings suggest that teachers who have served in the classroom have a broad array of elements they prioritize and identify as core to impacting student outcomes, but across 2.5 years of practice-based professional development, conceptions narrow and move from vague descriptions of classroom management toward more specific components of teaching practice. Results from this study indicate that veteran teachers can be influenced by professional development to develop a more shared understanding and conception of teaching practice rooted in the literature.

Science and mathematics teacher communities of practice: Social influences on discipline-based identity and self-efficacy beliefs
Samuel J Polizzi, Georgia Highlands College
Yicong Zhu, Stony Brook University
Brandon Ofem, University of Missouri – St. Louis
Sara L. Salisbury, Middle Tennessee State University
Greg Rushton, Middle Tennessee State University

ABSTRACT

Teacher communities of practice, identity, and self-efficacy have separately been proposed to influence positive teacher outcomes. We operationalize communities of practice as specific teacher social networks and explore empirical links to discipline-based teacher identity and self-efficacy beliefs across different teacher backgrounds and placements. We analyze survey data from in-service STEM teachers prepared at 5 university sites across the US, and compare science and math teacher groups. Data and exploratory factor analyses indicate that math teachers consistently report smaller communities of practice, and lower identity and self-efficacy scores. Correlations indicate communities of practice influence identity more strongly than self-efficacy, and imply mechanisms underlying positive teacher outcomes.

The Professional Journey of STEM Teachers in Egyptian STEM Schools: Transformation and Identity Evolution in a Time of Transition

Mohamed A. El Nagdi, University of Minnesota
Gillian H. Roehrig, University of Minnesota

ABSTRACT
Using a multiple holistic case study, the professional journey of STEM teachers in an Egyptian STEM school was explored. The study was initiated as a response to the growing STEM experience in Egypt both in terms of the growing number of schools, number of students admitted, and the effect of this experience on the overall education system in the country. Egypt started the STEM experience in 2011 with one school expanded to 15 schools across the country in 2019. This research is guided by following research questions: 1) How did Egyptian STEM teachers navigate the complex STEM experience? 2) How did Egyptian STEM teachers' identity evolve over the course of the STEM experience in a model STEM school in Egypt? 3)What do Egyptian STEM teachers identify as being important characteristics of STEM teachers? Teachers were found to have undergone a deep transformative change process from the traditional teacher into teachers with progressive mindset and different student-centered classroom practices. The teachers developed different conceptualizations of the STEM education, stressed the importance of collaboration, critical thinking and motivation for teachers seeking to work in a STEM setting, and considered themselves moving towards established STEM teachers' identity. Despite several challenges, the teachers still possess the energy for continuing that irreversible professional growth that eventually would have an impact on the larger context of the Egyptian education system.

Strand 10: Curriculum, Evaluation, and Assessment
Productively Engaging 'Community' in Project-Based Learning: Approaches to Supporting Meaningful Science Learning in Formal Classrooms

1:45 PM-3:15 PM, Columbia

Presider: Joseph S. Krajcik, Michigan State University

Developing usable scientific knowledge through community inspired project-based learning: A step towards science-based citizenship

Idit Adler, Tel Aviv University
Consuelo J. Morales, Michigan State University
Irene S. Bayer, Michigan State University
Tali Tal, Technion
Joseph S. Krajcik, Michigan State University

Developing a partnership through a community-based participatory research approach to develop,

enact, and sustain an equitable and inclusive educational innovation
Irene S. Bayer, Michigan State University
Idit Adler, Tel Aviv University
Consuelo J. Morales, Michigan State University
Ella Greene-Moton, University of Michigan
Stephen Modell, University of Michigan
Tali Tal, Technion
Toby Citrin, University of Michigan
Joseph S. Krajcik, Michigan State University

Why don't the Irises make seeds? Protecting rare endangered species in our community
Tali Tal, Technion
Hila Shefet, Technion
Nirit Lavie Alon, Technion

Comparing three elementary teachers' processes for engaging with PBL curriculum that leverages place
Emily C. Miller, University of Wisconsin Madison
Cory Susanne Miller, Michigan State University

Anchoring Project-Based Learning Around Our Community: Towards Relevant and Inclusive Science Learning for Elementary Students
Samuel Severance, University of California, Santa Cruz
Emily C. Miller, University of Wisconsin Madison

ABSTRACT
Supporting recent visions of science education where students engage in science learning that has relevance outside the four walls of the science classroom requires the development of novel curriculum that transcends traditional classroom boundaries. To meet this challenge of promoting more meaningful science learning within formal classroom settings, the teams of researchers in this related paper set argue for developing and implementing curriculum that engages conceptions of ‘community’ as part of a Project-Based Learning design frame. The papers in this session represent a range of research emphases centered on productively engaging community, including 6th grade students’ experiences while attempting to make sense of and address an imposing community health issue; how to engage community partners in order to effectively develop, enact, and sustain a large-scale 6th and 7th grade curriculum; 8th grade students’ efforts to study and protect a local flower in their community as part of a citizen science project; the sensemaking experiences of 4th grade teachers as they navigate the implementation of a curriculum rooted outdoors in the community; and 5th grade students’ experiences as they engage with a unit designed to leverage their funds of knowledge while exploring local freshwater phenomena.

Strand 11: Cultural, Social, and Gender Issues
Learning from Minoritized Youths' Experiences and Promoting Equitable Science Teaching through Research-Practice Partnership

1:45 PM-3:15 PM, Salon H
Discussant: Maria Varelas, University Of Illinois At Chicago, Maria Varelas, University of Illinois, Chicago
Presider: Hosun Kang, University of California Irvine,

Supporting Justice-Oriented STEM Teaching and Learning through Community-Engaged RPPs
Angela Calabrese-Barton, Univerity of Michigan
Kathleen A. Schenkel, Michigan State University
Edna Tan, University Of North Carolina At Greensboro

Understanding Minoritized Students' Experience in High School Biology: The Use of Electronic Exit Tickets
Kerri Wingert, University of Colorado at Boulder
William R. Penuel, University of Colorado
Douglas A. Watkins, Denver Public School District

"We need to step it up--we are basically the future": Latinx Young Women Doing Chemistry
Jasmine McBeath Nation, University of California, Irvine
Hosun Kang, University of California Irvine

"Your job is always take care of us": Engaging in a STEM-focused RPP with Refugee Youth
Edna Tan, University Of North Carolina At Greensboro
Aerin W. Benavides, The University of North Carolina at Greensboro
Ti'Era D. Worsley, University of North Carolina at Greensboro
Angela Calabrese-Barton, Univerity of Michigan

ABSTRACT
This session aims to better understand how students from historically minoritized communities experience science in classrooms where teachers and researchers co-develop and implement curriculum designed to promote equity. With the implementation of the Next Generation Science Standards, researchers are increasingly engaging in various forms of research-practice partnership (RPP) to transform science teaching and learning at schools. Equity-minded scholars advocate for long-term community-engaged partnerships where researchers and educators work together to address unequal opportunities to learn at schools. Yet, we know little about how students, in particular those from minoritized communities, experience curricula co-designed by researchers and educators with the goal of promoting equity in the context of RPPs. This session brings together four research teams from various institutions who engage in long-term RPPs to transform science instruction that is equitably consequential. Presenters will share (a) the nature of their partnership, (b) features of their co-designed curriculum, (c) methodological approaches to study student experiences (e.g., sources of data, instruments, analytical approaches), (d) findings about students' experiences in the designed learning settings, and (e) dilemmas or tensions emerging from their work. This session contributes to a limited but growing scholarship on RPP by attending to students' experiences mediated by co-designed curricula.

Strand 11: Cultural, Social, and Gender Issues
Reconceptualizing the Pathways and Experiences of Women of Color in STEM
1:45 PM-3:15 PM, Salon G
Presider: Catherine Quinlan, Howard University

A Tale of Two Tables: Wrestling with Belonging for Women of Color in STEM

Apriel K. Hodari, Eureka Scientific, Inc
Vanessa S Webb, George Mason University
Angela Johnson, St. Mary's College of Maryland

ABSTRACT
Analysis of undergraduate STEM degree attainment reveals that most colleges and universities where women, people of color, and women of color thrive are women's colleges or minority-serving institutions. But what about the exceptions, those few predominatly white institutions in which women of color are thriving? In this paper, we present common findings across three very different schools (a small liberal arts college, a large research university, and an enormous open-enrollment university) that outperform their peer institutions. Our analysis will contribute an improved understanding of the complex supports and challenges that women of color encounter in STEM, while presenting practical solutions used by successful institutions.

Self-Efficacy of African American Female Undergraduates in STEM disciplines

Carmen Bucknor, Oakwood University
Karen Benn Marshall, Oakwood University

ABSTRACT
Current research supports the statements from the National Science Foundation (NSF) and other scientific agencies that the science, technology, engineering and mathematics (STEM) academic disciplines and subsequent workforce must increase in diversity in the near future if our country is to see gains in employment. The purpose of this research study is to assess the perceived self-efficacy of African American STEM undergraduates. Social cognitive career theory framed this descriptive study, leading to the hypothesis that several variables (peer support, family support, institution support, math/science preparedness, demographic variables) would converge to predict feelings of self-efficacy. The study employed a sample of 62 African American female undergraduate college students enrolled in biology, chemistry, mathematics, computer science, engineering and psychology courses at a predominantly black institution. Regression models that included high school Math, perceived barriers and parental education level were significant. These findings highlight the importance of parental support and highlight the benefit of perceived challenges to feelings of self-efficacy.

Voices of Black Women in College Science Learning Spaces

Renee S. Schwartz, Georgia State University
Melissa Schoene, Georgia State University

ABSTRACT
This study explores experiences of five Black women in college level science classes. The women were enrolled at a community college, pursing non-science degrees. The experiences are gathered through the women's voices and perspectives as they tell their stories and describe interactions with science professors. Intersectionality theories and Black Feminist Thought illustrate the ways Black women in the U.S. have created a collective, specialized knowledge based on their unique backgrounds, cultural traditions, perspectives and experiences that result specifically from the intersection of their Blackness and womanness. This research also drew from critical race theory to explore the experiences of Black women as told by them. Their stories depict race-based differential treatment, including overt racism. The women perceived many science professors as obstacles to entry into the allied health field with

Black women often being singled out as incapable. The findings highlight the need for faculty acknowledgement and institutional recognition that racism inside college science learning spaces negatively affects the science learning trajectory of some Black women. The findings from the study may serve as a springboard to critical self-examination of science faculty regarding how they think about race and racism inside their classrooms.

Who's Who: "Women of Color" in STEM Education Research
Monica L Ridgeway Miles,
ReAnna S. Roby,
Charlotte A Agger,
Terrell R. Morton, University of Missouri - Columbia

ABSTRACT
Promoting diversity and inclusion within the fields of science, technology, engineering, and mathematics (STEM) is critical for meeting rising workforce demands and creating equitable structures. Women of color have made great strides regarding increased enrollment at the postsecondary level, yet they remain vastly underrepresented in STEM fields. There are challenges with addressing their underrepresentation given the ambiguous meaning of “Women of Color”. Using critical race feminism, we analyzed empirical articles in peer-reviewed journals from 2005-2019 to identify (a) how the term “women of color” was defined in the research, and (b) who was represented and how their presence or absence was integrated within the research findings. Findings and implications behind naming and representation are presented.

Strand 11: Cultural, Social, and Gender Issues
Storied-Identities as a Lens to Studying Science Identity
1:45 PM-3:15 PM, Salon I

Storied-Identities as a Lens to Studying Science Identity
Amal Ibourk, Florida State University
Lucy Avraamidou, University Of Groningen
Theila Smith, University of Groningen
Alison Mercier, University of North Carolina at Greensboro
Akira Harper, University of Massachusetts Dartmouth
Paul Le, University of Colorado Denver
Allison J. Gonsalves, McGill University
Anna T. Danielsson, Uppsala University
Henriette T. Holmegaard, University Of Copenhagen
Jennifer D. Adams, University Of Calgary

ABSTRACT
This symposium aims to explore and further develop how the construct of storied-identities, or stories that shape one’s identity, has been and is being constructed at the crossing of evolving and varied socio-cultural and political contexts as it is conceptualized and studied vis-à-vis science identity. As such, the symposium brings together researchers from different places of the world that use stories both as a theoretical construct (i.e., storied-identity) as well as a methodological approach (i.e., life-stories, autobiographies) to examine science participation. The symposium hopes to offer a contribution to the increasing knowledge base of science identity research at different levels: theoretical, methodological,

and practical. The symposium will contribute towards articulating the theoretical concepts and implications of studying science identity through a 'story-based' approach. The idea that science identity is a story resonates with sociocultural theory emphasizing the role of time and place on identity development and harmonizes in synergistic ways with the conceptualization of identity as situated, historical, relational, and multidimensional. This calls for future research examining narrative accounts of science identities, given the potential value of gaining an understanding of the stories that people carry with them and how these stories are nested in larger narratives.

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

NOS and Teachers' Perceptions

1:45 PM-3:15 PM, Portland

Presider: Christine V. Mcdonald, Griffith University

Entwining Scientific Facts and Moral Values in the Case of the Power of Words Experiment

Sein Shin, Chungbuk National University
Arif Rachmatullah, North Carolina State University
Rahmi Q. Aini, Kangwon National University
Jisun Park, Ewha Womans University
Minsu Ha, Kangwon National University
Jun-Ki Lee, Division of Science Education, Chonbuk National University

ABSTRACT

The ability to make rational value judgments based on scientific facts is one of the critical elements of scientific literacy. This is challenging, however, because facts are intertwined with values. Using a multiple-case study of elementary teachers who had taught the Power of Words experiment, this study qualitatively explored how facts and values become intertwined through the naturalistic and moralistic fallacies and motivated reasoning. In-depth interviews were conducted with seven elementary teachers. Six themes emerged from the transcribed interviews. The findings showed that all participants highly valued empowering elementary students to use positive words and that teachers believed that experimentation is an effective tool for justifying moral values. In conducting the experiment, some teachers obtained the expected result, which supported the importance of using positive language. However, some teachers obtained unexpected results, which stimulated them to interpret the facts through motivated reasoning. Moreover, one participant deformed the experiment to elaborate on the link between moral value and distorted facts. A model of dual-circular reasoning between facts and moral values is presented to explain the mechanism of moralistic and naturalistic fallacy and motivated reasoning.

Investigating science and religious education teachers' perceptions of argumentation

Sibel Erduran, University of Oxford
Liam Guilfoyle, University of Oxford
Wonyong Park, University of Oxford

ABSTRACT

In recent years, argumentation, or the justification of knowledge claims with evidence and reasons, has emerged as a significant educational goal, advocated in international curricula and investigated through school-based research. Research on argumentation has made connections to other areas such as indigenous knowledge and ethics in science. Surprisingly, however, the contrast of argumentation in science and religious education has been under-investigated although some educators have been concerned with the manifestation of science-religion debates in schools, particularly in relation to topics such as evolution and intelligent design. The purpose of this paper is to investigate how science and religious education teachers perceive argumentation in their subject and the other subject. Twenty-nine teachers were presented with an online survey in order to collect data on various aspects of their perceptions about argumentation. The empirical study used qualitative and quantitative methodology. Findings suggest that teachers of both subjects consider argumentation as a significant aspect of their subject although differences exist in how the teachers interpret argumentation in their discipline. Data suggest that there are statistically significant differences in terms of the frequency of use of pedagogical strategies that support argumentation in lessons. Contributions to broader research in science education are discussed.

Using History of Science (HOS) to Communicate Nature of Science: Multiple Cases of Instructors' Perspectives

William F. Mccomas, University Of Arkansas
Noushin Nouri, University of Texas Rio Grande Valley

ABSTRACT
Science educators accept that nature of science (NOS) should have a prominent place in school science curricula and generally agree on what the target aspects of NOS should be. This study highlights the special opportunity offered by the history of science (HOS) as a context and vehicle for teaching NOS by revealing HOS instructors' perspectives. Data were drawn from 15 instructors at 11 institutions who teach a HOS class as part of a national science and mathematics teacher preparation program. This resulted in multiple case studies and interesting conclusions revealed through cross case analysis. The results show several aspects of NOS that these instructors focused on in addition to HOS learning goals, accompanied by a variety of different approaches to including NOS. Few of the instructors believed that NOS should be a primary focus of a HOS class or that is should be taught explicitly; most instructors reported a belief that preservice teacher will learn about NOS as a natural outcome of a HOS class.

Strand 15: Policy
Examining Models of Change in STEM Education
1:45 PM-3:15 PM, Eugene
Presider: Sharon J. Lynch, The George Washington University

Critical Components of Inclusive STEM High Schools and STEM-Focused Elementary School: Opportunities for Vertical Articulation

Erin E. Peters-Burton, George Mason University
Ann House, SRI International
Vanessa L. Peters, Digital Promise
Julie Remold, SRI International

ABSTRACT

With the success of many STEM high school initiatives as well as the emphasis on the importance of STEM education generally, STEM-focused elementary schools have also been emerging across the country. Less is known, however, about STEM-focused schools for primary grades, including how they might be similar to and different from the high school models. To address this knowledge gap, this paper reports on a study to develop a logic model of STEM-focused elementary schools and provides a comparison between high school and elementary school levels. Multiple instrumental case study was used to develop school-level case studies for five elementary schools and eight high schools. The case studies were used to develop the critical components that were common across the cases. Comparison of the 17 critical components for elementary schools and the 14 critical components for high schools yielded 10 common components such as inclusive STEM mission and 21st Century skills. Components unique to elementary schools included interdisciplinary STEM lessons and school physical setting, while components unique to high schools included greater specialization in STEM subject areas. Information key for vertical articulation of STEM schools will be discussed.

Losing Science: An Examination of NGSS and STEM in Elementary Schools

Joanne K. Olson, Texas A&M University
Jacob Pleasants, Keene State University

ABSTRACT

Little is known about how NGSS is implemented under typical conditions. This four-year study examined 65 grades 3-5 classrooms across 13% of a medium-sized state's school districts to determine what is taught during allotted time for science, the curriculum materials adopted and in use before and after NGSS, and the quality of instruction. 14% of districts have replaced their science program with engineering or a makerspace, and over 20% of teachers observed have replaced science with engineering or "STEM" in practice. Only 32% of the districts observed have a science program that provides students with hands-on experiences that are accurate and developmentally appropriate. Only 37% of lessons taught during "science time" had an identifiable science concept, and of the lessons observed that could be considered science lessons, more than 65% taught misconceptions. In districts where engineering or maker programs had replaced science, teachers and administrators were unaware that science was missing. This study raises important issues about whether the vision of NGSS can be realized on a large scale when professional development is rare or non-existent, curriculum materials have substantial weaknesses or omissions, and time for science is limited. Adding engineering to the science curriculum has accelerated the decline of elementary science.

Supporting Diverse STEM Students' University Transfer: Research-Informed Policy Recommendations for Postsecondary Institutions and Policymakers

Stephanie Kay Ramos, Oregon State University
Jana L. Bouwma-Gearhart, Oregon State University
Cindy A. Lenhart, Oregon State University
Rican Vue, University of California, Riverside

ABSTRACT

Postsecondary education, including the attainment of science, technology, engineering, and mathematics (STEM) bachelor's degrees, continues to be a vital component for participation in the modern economy. At the same time, there is a call to diversify STEM fields and community colleges remain a relatively inexpensive STEM pathway entry for diverse students. Yet, the number of students that transfer from a community college to a four-year institution remains relatively low compared to

those that initially entered community colleges with the intent to pursue a STEM bachelor's degree. Key stakeholders tasked to address the transfer issues include two- and four-year institutions, state legislators, and policymakers. We propose four policy recommendations that implicate administrators at two-year and four-year institutions and state legislatures who enforce and create policies. Our work may also appeal to NARST members interested in supporting the success of diverse postsecondary students and learning about the realities and complexities of community college-to-university transfer in STEM.

Translating Research into Classroom Practice: Examining the Use of Research in Science Education Practitioner Journals (SEPJs)

Joseph A. Taylor, University of Colorado Colorado Springs
G. Michael Bowen, Mount Saint Vincent University
Patricia Patrick, Columbus State University
Ryan Summers, University of North Dakota
Marcus Kubsch, IPN - Leibniz Institute for Science and Mathematics Education
Abdirizak M. Warfa, University of Minnesota
Asli Sezen-Barrie, University of Maine
Selcen Guzey, Purdue University
Cathy P. Lachapelle, Museum of Science

ABSTRACT
This bibliometric study investigated the extent to which science education practitioner journals (SEPJs) cite science education research journals and other resources, and in what proportions. The study found that articles in the SEPJs investigated rarely cite the leading science education journals (average citation rate per article well below one). This result was not affected by article type and remains stable across 2013 to 2017. While results indicate that the article purpose affected the proportion of science education research journal citations, the proportion remains low with – in the best case – about 8% of all citations in The Science Teacher from 2013 to 2017. Implications for PCK development and the translation of research to practice are described.

Concurrent Session 6a – Roundtable Discussion
3:45 PM-4:45 PM

Strand 1: Science Learning, Understanding and Conceptual Change
Strand 1 Roundtable Session
3:45 PM-4:45 PM, Exhibit Hall

TABLE #5
Cutting-edge Evolution Research in the Hands of High-school Students: Students' Views of Scientific Inquiry

Bat-shahar Dorfman, Weizmann institute of science
Orna Dahan, Weizmann institute of science
Amir Mitchell, University of Massachusetts
Anat Yarden, Weizmann Institute Of Science

ABSTRACT
While technological breakthroughs have transformed biological research into a technology-driven science, K-12 students remain largely oblivious of the technologies and accompanying practices used in

research today. This further deepens the gap between school-based and authentic scientific inquiry (SI), which may affect students' views on science. In this novel remote lab-evolution program 100 Israeli high-school students were engaged in a cutting-edge research focusing on a current challenge in medicine – antibiotic resistant bacteria. The students planned and applied different antibiotic regimens to E.coli by remotely operating a robotic system in the US. We aimed to investigate how experiencing a cutting-edge research influenced the students' views on SI. The students filled pre- and post- program questionnaires aimed to assess their views on SI, as well as feedback questionnaires in which they described their experiences. Six students were interviewed. Following the program, transitions to more informed views about SI were observed. However, most of the students still held naïve views. This program offers a new perspective to SI in high-school. It allows to bridge geographical distances so that students from all over the world to be exposed to inquiry's dynamic and unexpected nature, to create a better picture of how science is actually done.

TABLE #1
Emergence of Student Argumentation
Qingna Jin, University of Alberta
Mijung Kim, University of Alberta

ABSTRACT
Scientific argumentation is often emergent and spontaneous when students interact with diverse backgrounds and knowledge to learn scientific ideas in classrooms. As research on argumentation as an emergent and spontaneous phenomenon has been very limited in classroom settings, this paper particularly aims to describe how elementary students' argumentative practice takes place during their science learning, and further explores factors impacting the emergence of argumentation. This qualitative case study was conducted a fifth-/sixth- grade science classroom in Canada over a 4-month period. Data resource included classroom recordings, interviews, and students' journals. It was found that student argumentation often occurred spontaneously when students explicitly questioned each other about the rationales for the proposed ideas and expressed different ideas. Moreover, teacher scaffolding with the scientific problem-solving context and students' appreciation of their peers' ideas were identified as the underlying factors that positively influenced the emergence of scientific argumentation.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Strand 2 Roundtable Session
3:45 PM-4:45 PM, Exhibit Hall

TABLE #2
Student experiences in a Problem-Solving studio.
Carmen A. Carrion, Georgia State University
Joseph Ledoux, Georgia Institute of Technology

ABSTRACT
Almost a decade ago the Georgia Institute of Technology began to implement a novel course structure, the Problem Solving Studio (PSS). The majority of technical engineering courses are lecture based where the instructor is driving the learning opportunities for the students. Creators of the PSS realized students were not engaged or interactive in their learning leading to the creation of the PSS. The setting and structure of the PSS allows for a much more interactive experience than is typically experienced in

traditional engineering courses. This study helps us unpack the key features and characteristics of this type of learning environment and their impact on students.Through this environment several features were found to be salient across various participants. The ability to work in dyads and teams impacted how the students approached problem solving. Additionally this environment promoted application to real world problem sets. Overall, the students found this novel interactive environment affected their learning.

TABLE #3

Interacting with Luna: Scientific Characters and 3rd Graders' Construction of Relationships with Science

Deborah Cotta, Universidade Federal de Minas Gerais
Danusa Munford, Universidade Federal do ABC
Elaine S. França, Centro Pedagógico (1-9 grades school) - Universidade Federal de Minas Gerais

ABSTRACT

In this study, we investigate how a group of 8-9 years old children constructs relationships with science after interacting with the characters of Earth to Luna! at home and participating in activities to share their experiences with theirs peers at school. This study was conducted in a public lottery school located in a big city in Brazil, in a classroom with 24 3rd graders (12 boys and 12 girls), for three months. The main data source was participant observation with records in field notes (Spradley, 1980) and in video. Moreover, we collected artifacts produced as students participated in the activities at school or at home (e.g., students' texts and drawings, and notes on the blackboard). The results indicate that the process of constructing relationships with science is not linear and it depends on interactions in classroom. Our study has potential to contribute to teachers' understandings of how to mediate interactions to promote a better use of media resources. Moreover, it can contribute with new insights into methodological approaches to investigate the influence of media with a focus on classroom discursive interactions that goes beyond the content of children's/instructor talk and also considers forms of participation.

TABLE #1

Variations in the construction of non-planned argumentation in two science classrooms

Danusa Munford, Faculdade de Educacao - Universidade Federal de Minas Gerais
Ana Paula Souto Silva Teles, Faculdade de Educacao - Universidade Federal de Minas Gerais

ABSTRACT

In this study, we adopt a contrastive perspective to investigate how non-planned argumentative situations are discursively constructed during activities on different topics in a middle school classroom and in an adult education classroom in Brazil. A naturalistic design utilizing qualitative research methods was employed in the present study. It can be characterized as a case study, informed by interactional ethnography. We adapted aspect of the Pragma-Dialetics theory of argumentation to learn about argumentation processes. We conducted participant observation with recording in field notes, combined to video recording. Results evidence how in both classrooms, teachers' actions helped to foster controversy, and consequently, supported a culture of argumentation. Students' forms of participation also contributed to variation in argumentation, as they interacted both with the teacher and with their peers. The study has potential to contribute to teachers' practice, teacher education and for a better understanding of diverse forms of argumentation that occur in science classrooms.

TABLE #2

The effects of flipped classrooms on students' math and science achievement: A systematic review

Gary W. Wright, North Carolina State University
Soonhye Park, North Carolina State University

ABSTRACT

Although the potential of the flipped classroom for promoting student learning is widely advocated, there is little empirical evidence supporting its actual benefits in terms of student learning outcomes. The purpose of this systematic literature review was to collectively examine the empirical research on flipped classrooms in formal, K-12 and post-secondary mathematics and science classrooms in order to gain insight into the effectiveness of this approach on student learning outcomes. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Moher et al., 2009) framed the identification, screening, eligibility and inclusion of articles for critical analyses. Data analysis indicated that a majority of the studies published within math and science classrooms were conducted in post-secondary settings and showed promise for positively improving students' understanding in calculus-based courses. Yet, there remains little objective, empirical evidence rejecting or accepting the flipped classroom as an effective approach for improving student learning in K-12 math and science classrooms. This systematic review provides a current understanding of the flipped classroom in K-12 and post-secondary math and science classrooms and serves as a basis for further exploring the design principles and effectiveness of flipped classrooms in these settings.

TABLE #2

Overcoming the Teacher-student Script - Student Persistence in Light of Constraints on Epistemic Data Agency

Julio Jamarillo, University of California, Berkeley
Michelle H Wilkerson, University of California, Berkeley
Lisette Lopez, University of California, Berkeley, Lawrence Hall of Science

ABSTRACT

We report on a study exploring the use of large-scale public data in seventh grade science classrooms. In preliminary prior work (Authors, 2019) we presented an episode in which students' development of epistemic data agency — their ownership and manipulation of data to answer a research question — was initially supported, then interrupted. This extends those findings to explore how epistemic data agency was fostered, constrained, and negated through interactions in the classroom environment across the data corpus. We ask: (1) What, specifically, hindered students' epistemic data agency during this activity? And, (2) How, if at all, did students overcome these hindrances to epistemic data agency? We identify specific constraints and student strategies, with implications for curriculum, instruction, and research.

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

Strand 3 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #3

Psychological underpinning of integrative-STEM education proposals

R. Bogdan Toma, Universidad de Burgos
Jesús Ángel Menéses Villagrá, Universidad of Burgos

ABSTRACT

The continuous decline of graduates in Science, Technology, Engineering and Mathematics (STEM) disciplines calls for more attention to STEM education at all stages of the educational system. Consequently, STEM educational policies, initiatives and programs are rising in recent years. However, the STEM agenda is lacking a clear conceptualization of what constitutes STEM education and how does it look like in the classroom. Accordingly, this study draws on social-constructivism learning theories to analyze the psychological underpinnings of integrative STEM proposals in order to contribute to a coherent interpretation of the teaching and learning processes that should take place when this type of approaches.

TABLE #3

Just Playing or Future Engineers? Early Engineering and Self-Regulation Capabilities among Young Boys and Girls

Taly Shechter, Bar Ilan University
Ornit Spektor-Levy, Bar-Ilan University

ABSTRACT

The study of developmental engineering thinking is gaining interest. The British Royal Academy of Engineering has recommended engaging in engineering education from childhood, specifying 6 Engineering Habits of Mind (EHoM): systems-thinking, problem-finding, visualizing, creative problem-solving, adapting, improving. However, few educational initiatives foster engineering thinking in young children, and few studies have been published. The first aim of this study was to identify indications of early EHoM, self-regulation, and metacognitive capabilities among preschoolers during a problem-solving play-like task: building a bridge with LEGO bricks. The second aim of this study was to explore gender differences in preschoolers' EHoM, self-regulation, and metacognitive capabilities. All participants (N=228) and their problem-solving processes were video-recorded, and a detailed rubric-based micro-analysis was conducted. The children were instructed to complete the task according to specific requirements (stability, height, and length). Most of the children managed to identify problems, set goals, test solutions, and choose one, while performing EHoM and displaying self-regulation capabilities. However, this study revealed significant differences between boys and girls. Boys performed significantly better in various EHoM, self-regulation, and metacognitive capabilities. Finally, data analysis revealed significant correlations between most variables of EHoM, metacognition and self-regulation capabilities—all key traits of engineers.

TABLE #4

Disjunctive Logic in the Language of Science

Shih-Wen Chen, Textbook Research Center, NAER
Chih-Hsiung Ku, National DongHwa University, NDHU
Chih-Chiang Yang, Nationa Ping-Tung University
Pei-Lun HAN, Textbook Research Center, NAER

ABSTRACT
Disjunctive logic is prevalent in our everyday language, which is typically interpreted by the conjunctive or connecting two words to indicate the alternative meanings of exclusion and inclusion. Exclusion means only one disjunct is true in a proposition, such as ‘publish or perish’, while inclusion indicates more than one disjunct to choose, like ‘coffee or tea?’ In the language of science, the conjunctive or typically also connects two vocabularies or sentences with scientific knowledge to interpret disjunctive logic. While encountering this academic language, it is necessary to distinguish semantically different categories of disjunctive logic for a better understanding. Therefore in this study, we aimed to investigate the types of disjunctive logic and its distribution in the primary school science textbooks of ‘Science: A Closer Look’ to help teachers and students take a closer look toward disjunctive logic. The results showed four categories of disjunctive logic embedded in the language of primary school science. Inclusion is the majority, slightly higher than Exclusion, and significantly greater than Equivalence and Conjunction. The conjunctive or repeatedly appears in the sentence, which makes it more difficult to distinguish the exact disjunctive logic. Finally, we offered some suggestions for facilitating a better reading understanding.

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

Strand 4 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #5

The House That STEM Built: Science, Technology, Engineering and Math in the Building/ Construction Trades

Grant Williams, St. Thomas University
Eric Hanenberg, George Street Middle School
Kayoe Stewart, Fredericton High School

ABSTRACT
Many middle level and high school students are unaware of how the topics they study in math, science and technology classes connect to real-world applications. There is a pervasive misconception that concepts covered in these courses are just a part of what must be learned in school and that they have little connection to the “real world” outside the classroom. Therefore, the proverbial questions, "when will I ever use this stuff?" and “who cares about this anyway?” continue to be asked. In response, this project highlights the Science, Technology, Engineering, and Mathematics (STEM) concepts and skills utilized in the design and construction of a family home so that students can develop an understanding of how what they are learning in school supports careers in the building and construction industry. We are developing a series of thirty 3-5 minute videos and accompanying lesson plans that document and highlight the various aspects of design, engineering, fabrication, and construction of an actual family home. This study seeks to investigate the imapct of the videos and lesson plans on students' understanding of and attitudes about STEM concepts and skills through their application to the building and construction trades.

TABLE #5

Implementation of Active-Learning During STEM Academy for Middle School Science Teachers

Tiffini Pruitt-Britton, Southern Methodist University
Elizabeth L Adams, Southern Methodist University
Leanne R. Ketterlin-Geller, Southern Methodist University

ABSTRACT

This study evaluated the growth in the implementation of STEM practices in middle school science teachers participating in a three-year-long intensive STEM Academy which included a Summer institute for professional development (PD), ongoing coaching and STEM-focused professional learning communities (PLC). Teachers were observed and scored on their level of implementation across time. We examine the amount of growth between time points to determine the effects of the STEM Academy on the implementation in STEM in middle school science classrooms. Observation tools evaluated teachers in four domains including classroom environment, lesson structure, implementation, and math/content knowledge. We observed that teachers' participation in the STEM Academy significantly influenced both implementation and mathematics/science content knowledge for the teachers. Further analysis revealed that teachers who had a decline in performance in either of the four domains showed no growth in either of the three remaining domains. The significance of this finding is the emphasis that must be placed on all four domains of an ideal math/science classroom since a decline in performance for either domain may result in failure to perform in any of the other domains.

TABLE #6

Fostering Productive NGSS Crosscutting Concept Implementation through Professional Collaboration

Jasmine Marckwordt, University of California, Santa Barbara
Jonathan Boxerman, WestEd
Ashley Iveland, WestEd
Kimberly Nguyen, WestEd
Edward D. Britton, WestEd

ABSTRACT

This research takes a qualitative look at the classroom observation and audio-recorded interview data of three teachers' implementation of the Next Generation Science Standards (NGSS) crosscutting concepts (CCCs) in the classroom. These teachers come from the same California NGSS Early Implementer (EI) school district and teach middle school science. They were chosen for this analysis because they have varied exposure to EI professional development and display a range of proficiency in CCC implementation. These exploratory data show that despite our original hypothesis, extent of EI professional development does not necessarily predict success in CCC implementation. Thus, we focus on the role productive collaboration (whereby teachers reflect on their practice, modify curricula based on student learning, etc.), as fostered by EI professional development, plays in implementation support. As an early stage of analysis, this work cannot be generalized yet to make definitive claims about CCC implementation support, but we recognize this work could be significant for teachers and researchers alike as they navigate putting NGSS standards into practice in classrooms by revealing the complexity of NGSS implementation, specifically with regards to CCCs.

TABLE #6
Implementing Effective Group Work in a Middle School Science Class
Massa Mafi, The University of New Mexico
Kathryn Watkins, University of New Mexico
Leila Flores-Duenas, University of New Mexico

ABSTRACT
In this study, an engaging activity through inquiry-based learning was chosen to motivate the 8th grade science students to stay on task and become active learners through critical thinking and peer communication. Sociometry technique was also used for grouping the students to enhance students' accountability, participation, collaboration, and learning. This was framed as a carboard-car project, where each group of students designed and built a car and tested the car on a ramp. The students needed to come up with their own designs, used their background technical knowledge, creativity, critical thinking, and problem-solving skills to build a car that could travel a certain distance with a certain speed. The result of this study determined high cooperation among members of each group, despite diversity in opinions. The result of this research also indicated that when the group members are selected meaningfully, a comfortable and engaging environment can be created for the students to work more productively toward a common goal. In addition, it is beneficial to offer more inquiry-based learning activities, and activities so that students can connect science to daily life experiences, because those encourage the students to develop a broad perspective about social engagement and group-work.

TABLE #4
Unpacking the meaning of teaching students to do science
Salih Yousef Faraj, Technion - Israel Institute of Technology
Amos Cohn, Oranim, Academic College of Education & Haifa University, and 'Archimedes Fulcrum' - Academy of Teachers Researchers in physics, ACHERET Center
Shulamit Kapon, Technion - Israel Institute of Technology

ABSTRACT
Recent position papers and policies in science teaching emphasize the importance of teaching scientific practices rather than focusing solely on scientific content. This study examines a unique community of physics teachers whose aim is to nurture the incorporation of authentic physics research experiences at the secondary school level. Located in a school, and associated with several schools, serving students from diverse cultural and ethnic backgrounds, the community trains and supports high school physics teachers to become research mentors, and mentor their students in long term (1-2 years) open inquiry projects that are carried out in the school. The goal of the current study was to examine the educational goals of doing research with high school physics students, as perceived by the staff and meta-mentors who constitute the core of the community. An overarching educational goal of teaching students to do science emerged from the interviews. The analysis highlights its different features, and how they are realized by the leading teacher-research-mentors in the community (N=12). The findings suggest that the leading teacher-research-mentors in the community are able to unpack and articulate ways of doing science with students that exceeds the descriptions of authentic scientific practices in the science education literature.

TABLE #6

Teacher Planning with Authentic Data: How do Secondary Science Teachers Integrate Analyzing and Interpreting Data?

Karen Woodruff, Montclair State University
Amanda M. Gunning, Mercy College
Meghan E. Marrero, Mercy College

ABSTRACT

This study presents an analysis of three secondary science teachers who took up the challenge of integrating authentic data into their lesson planning. While engaged in a graduate education course they learned about the use of authentic data as a teaching practice and engaged in discourse about choosing authentic data as a science specific pedagogy. They explored data connections in their lesson planning with the goal of enhancing real-world connections for students. Analysis of the data in this study suggests that teachers can take up authentic data sets from publicly available sources and plan for students to engage in meaningful analysis. Initial findings indicate that each teacher selected data from publicly available sources and integrated the data into their three-dimensional lesson planning. This work may be of particular interest to NARST members in Strand 4. Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies because it provides an in-depth analysis of the experiences of three teachers with examples of their selected data and how they chose to make connections to the three dimensions of NGSS. The research contributes to the ongoing conversation about how authentic data can be integrated into classrooms for deeper authenticity in science instruction.

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

Strand 5 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

The Success of Failure: Investigating Undergraduate Students' Experiences of Scientific Failure through a Phenminologial Lens

Sandhya Krishnan, University of Georgia

ABSTRACT

National reform in science education pushes for the practices of science in science education without taking into account the values that drive or are inherent to the culture of science, particularly that of failure. Whilst scientists have agreed that the experience of failure plays an important role in learning (e.g. Simpson & Maltese, 2017), we do not yet understand how students conceptualize the experience of failure in science. This study investigates how undergraduate students describe the experience of failure in science within an inquiry-based introductory biology laboratory course - a setting that represents the intersection between the culture of science and the culture of education. Students' experiences were collected through semi-structured interviews, and responses analyzed thematically. Preliminary results from a pilot study demonstrated that students sustain a naïve conception of failure in science: one that is more heavily tied to the culture of assessment than to the culture of science, but one with potential to increase student engagement and persistence in science. This study builds upon protocols and analyses from the pilot study to look at how students in introductory biology laboratory settings understood and defined failure through their experiences with science and science education.

TABLE #7
Students' Views on Science Learning Environments: Knowledge Generative vs. Knowledge Replicative
Ercin Sahin, University of Iowa
Ali Cikmaz, University of Iowa
Fatma Yaman, Bozok University

ABSTRACT
This study focuses on comparing how students view their learning experiences across different types of classrooms. Through describing students' perceptions of cognitive demands and value-making on learning tasks, this study highlights a significance of knowledge generative environments. We define knowledge generative environments as classrooms where students utilize oral and written language within the context of argumentation. Students create their own questions, design scientific experiments to search for answers, and support claims based on evidence. Being in the knowledge generative environment provides students with cognitive demand both in oral and written language. This feature of knowledge generative environments is to maintain students' active participation and to increase students' voice in classroom dialogues. Students can share their ideas freely, and they know there is no authority above them about the knowledge of the subject. Our findings show that, although their comfort levels are decreasing in the knowledge generative environment, students prefer where "brain hurts" for better learning. As students think more and work hard, they may increase their content knowledge, ownership, and motivation in science. Further studies are needed to explore how knowledge generative environments affect content knowledge, student ownership, and student motivation.

TABLE #7
Understanding Biology Teaching Assistants' Pedagogical Concerns: A Study of Undergraduate TAs Over One Academic Year
Hillary A. Barron, University of Minnesota - Twin Cities
Lorelei E. Patrick, Fort Hays State University
Julie C. Brown, University Of Florida
Sehoya Cotner, University of Minnesota

ABSTRACT
Undergraduate students in science classes are more engaged and demonstrate increased performance when instructional methods include authentic science practices and active learning strategies. Non-majors students (i.e., those enrolled in science classes to fulfill a degree requirement) typically receive instruction that is more lecture-based and prescribed, however, which contributes to disinterest, diminished self-expectations, and lower performance. Teaching assistants (TAs) often interact with undergraduate students more closely in science classes than faculty and thus could potentially have far-reaching impacts on non-majors students. Therefore, understanding how TAs think about their science teaching and the concerns they have about their methods can lead to designing more effective TA professional development. In this qualitative study, we explored TA written reflections and employed first- and second-cycle analysis techniques to identify themes reflecting TAs' perceptions of their science teaching and concerns for improvement. We found that TAs' pedagogical concerns centered on three themes: subject-specific concerns, student-centered concerns, and delivery and presentation concerns. Further, these concerns changed over time and varied across TA experience level. Through this study, we offer insight into examining how TAs' pedagogical concerns evolve and discuss the implications for TA professional development.

TABLE #7

Sexual Selection Instruction: an Evaluation of Relationships Between Theory Pedagogy, Gender Self-stereotyping, and Student Misconceptions.

Sarah H. Spaulding, University of Louisville
Linda C. Fuselier, University of Louisville
Laura R. Novick, Vanderbilt University

ABSTRACT

Sexual selection (SS) is commonly taught in introductory and upper-level university biology courses, and though an updated understanding of SS has been available in the literature for decades, the model presented to students in textbooks and the classroom fails to reflect the diverse range of, and flexibility in, the reproductive behaviors and interactions of organisms that is reflected in the literature. Rather, the classic version of SS (which has been criticized on the basis of androcentric bias) is regularly taught in universities; this both presents an inaccurate depiction of the theory and promotes biological gender essentialism by encouraging students to believe that sex roles are inflexible. We created a content assessment to evaluate student comprehension of SS when presented with classic vs. expanded examples of SS and used validated instruments to measure their beliefs about gender stereotypes and essentialism. Our study identified three common misconceptions about SS held by students and found that focusing on an expanded view of SS does not interfere with student understanding of the theory. The application of gender stereotypes by students in open-ended responses was ubiquitous and occurred regardless of student demographics or the manner in which SS theory is presented.

TABLE #8

The Role of Making in Supporting Undergraduate STEM Education

Edward G. Lyon, Sonoma State University

ABSTRACT

Undergraduate students, particularly from traditionally marginalized groups such as students of color, and women, can experience pronounced challenges in persisting and succeeding in STEM coursework. In response, institutions are seeking ways to support students through, for example, (1) instructional practices that emphasize active learning and (2) freshman/sophomore year experiences that promote dispositions and equip students with support to navigate the critical early undergraduate years. Yet, an unexplored mechanism for addressing these issues is the role of learning experiences centered around making and the maker movement, which can allow students to play and tinker with ideas intune with their own dreams and creative outlets. We designed, implemented, and researched a semester long general education undergraduate course and associated makerspace in a four year public institution. We discuss findings from an end of the course interview with sophomores about their conceptions of making, learning STEM, and STEM related careers. Preliminary findings point toward student conceptions of making consistent with our own (and the course's) theoretical stance, but not consistent when discussing how they learn STEM. The findings contribute to an emerging area of science education research around Making that, unlike most studies, is focused on undergraduate STEM education.

TABLE #8
Building Student Confidence through Micro-Internships at a Central California Community College
Brae Salazar, BSCS Science Learning
Zoe E. Buck Bracey, BSCS
Mohammed Yahdi, Hartnell College

ABSTRACT
We report on early findings from a five-year study of a program at a central California community college, in which students engage in applied STEM learning through “micro-internship” experiences. Micro-internships are designed to reduce inequalities inherent in the traditional internship paradigm by providing access to professional and research skills for students who don’t have the opportunities and/or confidence to participate in a full-length internship. Early pre/post student survey results indicate that participating in a micro-internship significantly increases students’ confidence to continue to pursue opportunities to develop within the STEM pipeline. We hope that sharing the work of this project with NARST attendees could lead to productive conversations about interventions that build on the strengths of community colleges and contribute to more equitable education outcomes and a more diverse STEM workforce in the United States.

TABLE #8
Epistemic Analysis of Textbooks in Quantum Mechanics
Ashwin Krishnan Mohan, Pennsylvania State University

ABSTRACT
Quantum mechanics (QM) has always had a reputation for being a subject that is in equal parts interesting to peruse, exciting to learn, and notoriously difficult to understand. QM has become ubiquitous in most undergraduate science curricula and even in high school curricula in varying levels of complexity (Shiland, 1997; Lautesse et al., 2015; Krijtenburg-Lewerissa et al., 2017). However, the necessity of teaching quantum mechanics at an early enough level in education has led to a large range of documented conceptual difficulties. Most solutions and interventions to try and remedy the situation that can be found in the literature are in terms of instructional strategies by teachers in the classrooms (Cataloglu & Robinett, 2002; Zhu & Singh, 2012) without considering the representations of quantum mechanics in student texts. Two textbooks in QM that are commonly used in undergraduate and graduate courses around the world, Introduction to Quantum Mechanics by David J. Griffiths (Griffiths, 2005), and Modern Quantum Mechanics by Jun J. Sakurai and Jim Napolitano are analyzed in this work. A stronger, more considerate representational framework is argued for along with a need to move away from textbooks that look at problem solving as the only means of understanding quantum mechanics.

Strand 6: Science Learning in Informal Contexts
Strand 6 Roundtable Session
3:45 PM-4:45 PM, Exhibit Hall

TABLE #9
Embedded Assessment Pursuits: Identifying Important, Relevant, Accessible but Hidden Skills of Citizen Scientists
Cathlyn Stylinski, University Of Maryland Center for Environmental Science
Veronica Del Bianco, University of Maryland Center for Environmental Science
Karen Peterman, Karen Peterman Consulting, Co.

Andrea Wiggins, University of Nebraska at Omaha
Rachel Becker-Klein, Two Roads Consulting
Tina Phillips, Cornell University

ABSTRACT
Embedded assessment (EA) is particularly well-suited for evaluating citizen science volunteers' proficiency of science inquiry skills; however they remain uncommon in informal education. Using design-based research, we are examining processes to streamline EA development by building on existing data validation procedures within five citizen science projects. Here, we focus on the critical first step of supporting citizen science project leaders in identifying appropriate skills that are important, relevant, accessible, and potentially hiding in plain sight in their existing data. Our research reveals that the project leaders can bring broad but uncertain conceptualizations of volunteers' skills relevant to their citizen science efforts. These leaders need time and support to refine expansive notions of skill into concrete and clearly defined specifics that can be assessed from their existing data. Our research shows that identifying appropriate skills for EA is a complex multi-step procedure that benefits from supporting oral and written tools. Understanding the processes for developing embedded assessment is valuable for education research in diverse venues.

TABLE #9
Brazilian visitors' motivation to a museum: psychometric properties of an instrument through combination of methods
Ana Cláudia C. Kasseboehmer, University of São Paulo
Rosana F. Martinhão, University of São Paulo
Kenia N. Parra, Federal Institute of Education, Science and Technology of São Paulo
Daniela M. L. Barbato, SEB Institute of Education

ABSTRACT
The visit to a science museum may be manifested through complex and dynamic motivations which, according to the literature, are under-investigated in a Brazilian context. In this study, an instrument has been modified and applied to 202 visitors up to 15 years in order to investigate motivation for visiting. Combined application of Exploratory Factor Analysis and the Information Bottleneck method revealed that 17 out of the 20 initial items in the questionnaire aligned with three dimensions of motivation. The main motivation was learning desire, while entertainment and interaction motivations were significantly less important. The study provided relevant evidence regarding the motivations of visitors that will be valuable in improving the activities of the museum. The implications of our findings for future research are discussed.

TABLE #9
Debating Socio-Scientific Issues on Social Media
Keren E. Dalyot, Technion Israel Institute of Technology
Ayelet Baram-Tsabari, Technion - Israel Institute of Technology

ABSTRACT
Over the last decade, the internet has become a major force influencing many aspects of our learning life. Specifically, social media play an increasing part in learning and lifelong learning. In Israel, Facebook (FB) is the leading social media, with approx. 70% of the population subscribed. This paper analyzes a specific public science discourse on an open FB page. The FB page belongs to a TV program and the discussion analyzed followed the airing of an episode about an emerging social scientific issue: non-

ionizing radiation (mainly from electrical appliances), and characterizes the discourse that took place. We examined how adults engage in social media with scientific content that is relevant to their lives, and how social media acts as a hub for such discussions. We conclude that by enhancing the role of scientists in public discourse, we can potentially have a more fruitful and scientific online discussion and discourse and thus contribute to life-long learning of science.

TABLE #20

Staying in Science: An examination of persistence with STEM in historically under-represented youth

Rachel L. Chaffee, American Museum of Natural History
Preeti Gupta, American Museum of Natural History
Karen Hammerness, American Museum of Natural History
Timothy Podkul, SRI International
Kea Anderson, SRI International
Daniel Princiotta, SRI International
Alexandra Ball, SRI International
Daniela Saucedo, SRI International

ABSTRACT

This longitudinal study aims to deepen our understanding of why youth from underrepresented backgrounds with deep interest, aptitude, and achievement in science do or do not pursue STEM college degrees and careers. Drawing on data from approximately 500 urban youth participating in a mentored science research internship program, we examine the potential role of youths' mentored research experiences and their social networks in youths' STEM pathways. Utilizing a learning ecology lens, we explore the role that engagement in science practices, a science community of practice, and relationships with significant adults as well as peers play in supporting youths' mitigation of challenges they face both during and after their research experiences, as they transition from high school to college. We posit that youth who participate in supportive science research mentoring experiences while in high school gain specific skills and build social networks that positively influence their academic activities while in college, orienting them towards a STEM career. Findings from this study may contribute new insights into the features of informal and formal education settings that may best support the STEM pathways of youth from diverse socioeconomic and racial backgrounds, particularly first-generation college students and youth from immigrant families.

Strand 7: Pre-service Science Teacher Education

Strand 7 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #10

FAVSTE: A Framework for Analyzing Video in Science Teacher Education

Michelle Forsythe, Texas State University
Brett Criswell, West Chester University

ABSTRACT

Although there appears to be consensus that the use of video in science teacher education (either of a teacher's own practice or of the practice of others) can support pedagogical development, significant questions remain unanswered about how best to support this use. One of these open questions -- 'How can teaching teachers to identify and interpret relevant classroom events on video clips improve their

capacity to perform the same activities in the classroom?' -- has been the core concern of a group of science teacher educators for the past two years. This collaborative has developed, tested, and refined a framework for supporting the emergence of video analysis skills within science teacher education courses and for applying these skills to reflection by teacher candidates on their own teaching practice. This poster presentation presents an overview of this framework -- which we have designated the Framework for Analyzing Video in Science Teacher Education [FAVSTE] -- and details the sources for the various elements within the framework.

TABLE #10

How To Give Effective Feedback To Pre-service Teachers About Their Representational Competences?

Büsra Tonyali, University of Duisburg-Essen
Mathias Ropohl, University of Duisburg-Essen
Julia Schwanewedel, Humboldt University of Berlin

ABSTRACT

Planning and preparing instructional materials are part of teachers' daily work and can be done in many ways. Especially in science education, these materials are characterised by subject-specific representations. As previous research indicates, working with representations is a substantial challenge for pre-service teachers which requires support. In this project, we use the high potential of internally and externally provided feedback to address this challenge. An intervention study will be carried out in a pre-post-design during in-service teacher training that follows in Germany on university studies. Dependent variables are pre-service teachers' content knowledge, pedagogical content knowledge, and beliefs regarding representations (N = 120). In order to analyse the effect of feedback on these representational competences, an evaluation sheet for providing both forms of feedback has already been piloted and shows an effectiveness. The piloting of the test instruments with N = 50 master students has just been completed and confirms the lack of representational competences. Overall, the test indicates sufficient characteristics. Results from further statistical analyses will be presented at the conference.

TABLE #11

Pre-service Teachers' Ideas about What to assess in Modeling and Filters affecting Modeling-Based Assessment Planning

Young Ae Kim, University of Arizona
J. Steve Oliver, The University of Georgia

ABSTRACT

This qualitative study examined secondary prospective science teachers' learning and enactment of instructional practices and assessment plans related to modeling. The prospective teachers were asked to create an assessment rubric using modeling which served as a main data source in this study. Examination of five cases showed that the prospective teachers developed knowledge about what to assess in modeling-based instruction and assessment in relation to what to teach in modeling. We found the prospective teachers mainly planned to assess students' content knowledge and understanding of concepts. In addition, the preservice teachers rarely planned to assess modeling practice and meta-modeling knowledge in the rubrics. Secondarily, our analysis indicated the filters affecting preservice teachers' decision-making in planning modeling-based assessment such as fairness (objectivity), authenticity, selection of the forms of models, purpose of assessment, and artistic ability in secondary science classrooms. Pre-service teachers' struggles to construct well-designed assessment tasks and instruction are important and meaningful, but also points to the need for support of prospective

teachers' learning of modeling-based assessment. In addition, our analysis also showed that many prospective teachers needed additional instruction in order to learn about the importance of meta-modeling knowledge when dealing with models and modeling.

TABLE #11

Teaching Experiences for Undergraduates: Exploring Measures of Efficacy and Teaching Effectiveness

Maria S. Rivera Maulucci, Barnard College
Adam Stefanile, Teachers College, Columbia University
Alanna Gibbons, Teachers College, Columbia University

ABSTRACT

The Summer STEM Teaching Experiences for Undergraduates from Liberal Arts Institutions (TEU) program is developing and testing a program that provides undergraduate STEM majors with an immersive summer teaching experience similar to the immersive science research experiences for undergraduates programs (REUs). Each summer undergraduates (TEU interns) from a network of liberal arts institutions provide summer enrichment courses for high-need, urban, high school students. The program includes tight integration of a high-quality, discipline-specific pedagogy course with a supervised teaching practicum. This paper reviews the findings from three measurement tools developed to assess the impact of the program on science TEU interns, measures of individual self-efficacy for teaching high-need, public school students, team teaching efficacy, and a teaching observation checklist. Data include pre-post surveys, interviews, lesson observation checklists, self-assessments, and direct observation notes of project investigators. Analytical methods include descriptive and analytical statistics for small samples and a comparative case-study approach. The findings show that attention to situational demands in designing the efficacy surveys and observation checklists provides more nuanced and robust data that can be used to derive program-specific changes, enhance the TEU interns' sense of efficacy, and increase the likelihood that they will choose to become teachers in high-need schools.

TABLE #11

Pre-service teachers' successes and challenges around enacting a social justice framework of science teaching

Jarod Kawasaki, University of California - Los Angeles
Deborah La Torre, National Center for Research on Evaluation, Standards, and Student Teaching (CRESST)
Imelda L. Nava, UCLA
Jaime Park, UCLA Center X
Annamarie Francois, UCLA Center X

ABSTRACT

We report on eight novice science teachers' efforts to understand and enact a social justice framework of science teaching developed locally by university teacher education faculty. Enacting rigorous and equitable science teaching within schools serving low income students from communities of color can be difficult for novice teachers. Our perspective on social justice science teaching relies on a subset of instructional practices that support students learning and participation in rigorous science instruction and creates equitable access to science content for all students in the classroom. We analyzed classroom observation ratings and video recordings of classroom teaching in order to understand novice teachers' development as social justice science educators. We found evidence that teachers improved across the academic year in their efforts to enact social justice science teaching. In addition, there

remain a few different challenges. In this session, we share our findings along with video excerpts to depict novice teachers' classroom teaching and discuss the implications for science teacher educators that are supporting novice teacher learning and development around a social justice framework.

TABLE #11

Compare Synchronous and Asynchronous Interaction for Online Science Teacher Preparation

Jianlan Wang, Texas Tech University
Yuanhua Wang, Texas Tech University

ABSTRACT

Online teacher education is an important alternative in response to the problem of teacher shortage. The format of interaction is critical in leveraging social and intellectual interaction between learners. Yet, few studies have examined this issue in online teacher preparation. In this study, we examine two commonly used interactional formats that are synchronous and asynchronous interaction. We separate 145 pre-service science teachers into four groups experiencing face-to-face interaction (G1), synchronous interaction through online meetings (G2), asynchronous interaction through online forum (G3), and individual work without interaction (G4). The four groups receive the same curriculum and the impact of instructors on interaction is carefully controlled. We compare the social and cognitive presence and science teaching using the 5E model between the four groups. The results show that the two groups with synchronous interaction (G1 and G2) outperform the one with asynchronous interaction (G3) and no interaction (G4) in social presence, cognitive presence, and science teaching. Person correlation further connects interactional format, pre-service teachers' sense of learning community, and their teaching practice. The findings provide empirical evidence supporting the importance of interaction and synchronicity as an important indicator of the effectiveness of online interaction. Implications are also discussed.

TABLE #12

Exploring prospective teachers' development of knowledge for teaching during their practicum

Lu Wang, University of Georgia

ABSTRACT

Engaging in practicum is an important part in teacher education program as it provides prospective teachers opportunities of learning to teach in an authentic context. Understanding prospective teachers' knowledge development in this context as they observe their mentor teachers will contribute to our understanding of how they learn and further provide adequate supports for them. This study investigated a group of prospective teachers' knowledge development in their practicum as describe by the PCK framework . Results suggested four salient features of prospective teachers knowledge development in the practicum: (1) PCK development is idiosyncratic; (2) KIS and KSU are the two most common components PSTs developed and their connection is central among all the connections; (3) KAS is the least PCK component that PSTs developed; (4) PSTs draw from different sources to build their PCK.

TABLE #12

Using Multiple Levels of Representations to Teach Physical and Chemical Change in Science Classrooms

Funda Savasci-Acikalin, Istanbul University-Cerrahpasa
Meryem Demir-Guldal, Istanbul University-Cerrahpasa

ABSTRACT

The purpose of the study was to investigate how preservice teachers use multiple levels of representations to explain and teach physical and chemical changes in science classrooms. Research questions were designed as follows: (a) How do preservice teachers understand physical and chemical change? (b) How do they teach physical and chemical change in grade 6-8? A qualitative research method was adopted in the study. Participants were forty two preservice science teachers. Data were collected from open-ended questionnaires and lesson plans. Data collection took four weeks. Firstly, participants were asked to explain and draw their understanding after watching four videos related to physical change and chemical change at the macroscopic level. Secondly, they were asked to prepare lesson plans for teaching physical and chemical change. Findings indicated that participants had more scientific representations of physical change than those of chemical change. Most of the participants had difficulty to explain dissolving salt in water (19%) and sublimation of dry ice (28%) while they had more scientific representations related to dissolving sugar and ink in water. A majority of the participants did not have scientific representations of chemical changes. An analysis of lesson plans indicated that participants did not integrate multiple levels of representations to teach physical and chemical changes in their classrooms.

TABLE #12

Preservice teachers' implementation of NGSS-aligned and social justice-oriented science teaching

Hildah K. Makori, Iowa State University
Gale A. Seiler, Iowa State University

ABSTRACT

Science standards play an important role in teacher preparation such as the Next Generation Science Standards (NGSS) being implemented in many States. In addition, equity and diversity are emphasized in the NGSS hence, the need for teacher preparation programs to foreground social justice science teaching. However, there is little research on how preservice teachers (PSTs) prepared within the NGSS framework implement them, given the shift from content-driven learning to practice-based learning, and if/how PSTs enact social justice science teaching. Using the concepts of habitus, structure, and agency, this research investigated the affordances and constraints of enacting NGSS-aligned and social justice-oriented practices during student teaching, when enrolled in a science teaching methods course that emphasized both approaches. The analysis showed that cooperating teachers served as structures that might constrain or support the change of PSTs' habitus of practice. The view of science knowledge as objective and neutral and the ways in which social justice is thought of and presented constrained PSTs' implementation of social justice science teaching. However, there was evidence of more awareness in promoting equity in PSTs' teaching. Therefore, PSTs' habitus of practice as it relates to NGSS was changed to varying degrees among the three PSTs.

TABLE #12

Recruiting and preparing diverse STEM professionals to become highly effective teachers

Natalie S. King, Georgia State University
Christine D Thomas, Georgia State University

ABSTRACT

Science and mathematics teacher educators nationwide are being faced with the challenge of preparing pre-service teachers to not only enter into the teaching profession, but to remain. Unfortunately, this crisis is not new, particularly as it relates to secondary science and mathematics educators where qualified individuals often seek employment in non-teaching positions, change careers, and leave the profession due to job dissatisfaction, personal reasons, or retirement. School factors that often contribute to teachers leaving the profession are unrealistic expectations from administrators, inadequate resources, difficulty managing the classroom, out-of-field teaching assignments, and unpreparedness to teach assigned science and mathematics content. School districts in low-income urban environments disproportionately shoulder many of these challenges leading to increased teacher attrition rates. Many schools in urban contexts have higher proportions of Black/Latinx students, who face a unique challenge of having a cultural mismatch between their lived experiences at home, and the White middle class normative culture that exists in their formal schools. In this presentation, we share evidence-based practices to recruit and prepare STEM professionals who are committed to teaching in high-need secondary schools. We also present our methods for engaging STEM professionals in innovative professional learning experiences for their development as teacher leaders.

TABLE #13

Community Engaged Scholarship: Mixed Methods Assessment of Self-Efficacy of PSTs in Informal STEM Microteaching PD

Jacqueline N. Ekeoba, University of Houston
Paige K. Evans, University Of Houston
Leah Y McAlister-Shields, University of Houston
Mariam Manuel, University of Houston
Ramona C Mateer, University of Houston

ABSTRACT

Effective instruction relies heavily on the influence of professional experience equipping preservice teachers (PSTs) with pedagogical skills. In this community engaged scholarship project, preservice teachers majoring in science, technology, engineering, and mathematics (STEM) topics engage in professional development provided by in-service STEM teachers and various university STEM faculty in preparation for microteaching in an informal STEM teaching context – a summer camp for secondary school-age children. Individual constructs of self-efficacy of these PSTs were assessed quantitatively through a paired samples t-test and qualitatively through open-ended questionnaires.

TABLE #13

Leveraging Community Asset Mapping in Preservice Secondary Science Education

Kirsten K. Mawyer, University of Hawaii
Heather J. Johnson, Vanderbilt University

ABSTRACT

To support preservice science teachers (PSTs) in learning about their students and the many dimensions of their lived experiences, teacher educators can engage PSTs in creating a community asset map. The

goal of community asset mapping is to gain a deeper understanding of the social, cultural, and historical contexts of students' communities and identify assets that can be leveraged in the design of learning opportunities. This study examines how PSTs envision leveraging community assets in their science instruction. Results show that PSTs are able to identify community assets and how they might use those assets to provide access to resources, learn about careers, build students' science identity, connect science to another field, connect science and place, connect science, place, and culture, and support advocacy. Also, we found that PSTs may have limited vision regarding how to leverage the affordances of community assets to create engaging and inclusive science learning experiences. This study contributes to the research and practice of science teacher preparation by highlighting a robust task that provides PSTs an entry point for engaging in the work of community asset mapping with the broader goal of equitiable teaching that supports meaningful science learning for all students.

TABLE #13

Experiences in Science and Mathematics Methods Courses and Science Teaching Efficacy

Sheryl L. McGlamery, University Of Nebraska Omaha
Bridget A. Franks, University of Nebraska at Omaha
Saundra L. Shillingstad, University Of Nebraska Omaha

ABSTRACT

This study represents a two year effort to explore and describe the development of elementary science teacher efficacy during field experiences in methods courses. Each participant in the study was given the STEBI-B instrument as a pre/post survey to measure any changes in the teacher candidates efficacy. Further, a qualitative questionaire was given to determine specific effects of other components of the methods courses. A paired t-test was used to determine the results of the STEBI-B. Staitical signicance was found in both subscales of the STEBI-B. The qualitative data was coded and found the field experiences to be the most significant component of the methods courses for influencing efficacy development.

Strand 8: In-service Science Teacher Education

Strand 8 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #14

Knowing Your Coach's Role: Navigating a Coaching Relationship at the Boundaries of STEM Integration

Justin R McFadden, University of Louisville

ABSTRACT

The current study examined how an elementary teacher interpreted the enactment of a STEM coach's role. The findings of the case study reported detail how a coach's role was misinterpreted. Additionally, the data presented reveal how strict adherence to a presupposed coaching stance (i.e. reflective) or role, can limit the fruitfulness of a teacher-coach relationship. Finally, and given the likelihood coaches and teachers possess varying forms of expertise, the study contends that when paired with elementary teachers, a STEM coach might employ more direct coaching supports so individual teachers can implement and experience the potential benefits of new, instructional strategies.

TABLE #14

K-8 Teachers Planning for Supporting Sensemaking through Engineering Learning Cycles

Anna Maria Arias, Kennesaw State University
Allison Antink-Meyer, Illinois State University

ABSTRACT

New reforms focus on the integration of engineering and science practices (SEPs), disciplinary core ideas (DCIs), and cross-cutting concepts (CCs) in support of deeper sensemaking and understanding in both science and engineering as well as in the connections between them. However, teachers need new abilities and knowledge to support this sensemaking. One strategy for supporting teachers is to draw on their existing curricular resources and understandings in conjunction with meaningful, sustained professional development. To examine the potential of this strategy, we analyzed teachers' lesson plans and interviews developed by thirty K-8 teachers during a two-year professional development focused on engineering design. The analyses of the plans and teacher interviews identified areas of strength, growth, and continued challenge for the teachers. One strength seen in the plans was the support for students to share and justify their thinking during the engineering design process. Almost all plans included opportunities for students to justify their claims or designs with evidence or reasoning. A challenge existed around giving students epistemic agency; many plans did not allow students the agency around deciding how to investigate the problem. The study has implications for teacher educators hoping to support engineering design connected with science learning.

TABLE #14

The Role of Self-Talk in Supporting Teachers' Implementation of Inquiry-based Instruction in High-Need Urban Schools

Stacy Olitsky, Saint Joseph's University

ABSTRACT

Teachers who are dedicated to inquiry-based instruction in high-need urban schools face challenges that include lack of resources and the prevalence of rote instruction. This four-year study, which focuses on two science teachers, investigated the experiences and internal strategies, including self-talk, that may enable persistence with inquiry-based instruction in high-need schools. The results indicate that implementing instructional reforms towards increasing inquiry can pose considerable challenges, including failed classroom interactions and difficulty getting students to transition from traditional instruction. However, through self-talk strategies that include repetitive, motivational statements, recalling supportive voices of mentors, and reframing negative classroom interactions as puzzles to be solved, teachers may be able to generate sufficient internal solidarity to foster persistence in the face of obstacles. In this study, structures that supported productive self-talk included autonomy over curriculum, sense of belonging, positive interactions with supervisors, and access to non-evaluative mentoring. Overall, the results suggest there may be value in teacher preparation and professional development that has a specific focus on self-talk strategies and managing emotions. In addition, this study affirms the value of mentors not only for providing advice, but also providing ingredients for solidarity-producing self-talk, such as positive feedback and statements that reinforce values around teaching.

TABLE #15
Teachers' Interpretations and Enactments of Storyline Curriculum
Casandra Gonzalez, Boston College
Katherine L. McNeill, Boston College

ABSTRACT
In this study, we explore the ways that teachers interpret and enact an "ambitious" middle school science storyline curriculum. After teachers participated in a 4-day professional development in which they were introduced to the philosophy and structure of the curriculum, we interviewed fourteen teachers who discussed, among other things, their interpretations of their and their students' roles in driving classroom learning. This study analyzes those interpretations, and goes on to follow three teachers with varying ideas about student/teacher roles as they enacted the curriculum. The resulting variations in implementation reflect the teachers' interpretations as voiced in their post-interview. Implications are discussed for future iterations of this professional development and for any curriculum or professional development that promotes the centering of student voice and student questions as a driver for learning.

TABLE #15
US and Japanese Middle and High School Science Teachers' Conceptions of Inquiry-based Learning Practices
Noemi Waight, University at Buffalo
Koichi Furuya, Joetsu University of Education
Melinda Whitford, University at Buffalo

ABSTRACT
An inquiry-based teaching and learning questionnaire was administered to in-service middle and high school science teachers in the Northeastern US and Japan and documented how they (a) defined and understood inquiry and (b) how they enacted inquiry in their science classrooms. The questionnaire was adopted from the Mathematics and Science for Life [Mascil] (2014) project that documented teachers' views, beliefs, and current practices related to implementation of inquiry-based learning (IBL) in thirteen countries (1132 teachers) in the European Union. The findings revealed no clear patterns with respect to US and Japanese teachers' understandings of inquiry and enactment of inquiry. In fact, there was tremendous variability across the factors that informed on conceptions of inquiry and how inquiry was enacted in practice. In terms of the association of knowledge of inquiry and enactment of inquiry, the correlation coefficients for implementation were all statistically significant for US teachers. Japanese teachers did not reflect the same pattern as observed with their US counterparts. The results have implications for understanding how reform efforts such as inquiry-based teaching and learning are understood and realized among in-service science teachers in industrialized nations.

TABLE #15
Linking Science & Literacy for All Learners
Rachel Lee Juergensen, University of Missouri - Columbia
William L. Romine, Wright State University
Jiyung Hwang, University of Missouri - Columbia
Bill Folk, University Of Missouri
Amy Lannin, University of Missouri - Columbia
Torrey Palmer

Delinda van Garderen, University of Missouri - Columbia

ABSTRACT

Many students do not have the critical skills necessary to engage in complex text. The reciprocal relationship between science and language learning, including literacy skills, is well established. Complex texts receive limited attention within the content areas and an emphasis on supporting students with complex texts is relatively sparse. For this study, teachers of 6th-8th grade participated in a week-long summer professional development where they learned about multimodal text sets and linked inquiry. These teachers implemented the multimodal text sets, conducted Scenario-Based Assessments, and participated in teacher surveys and interviews about implementation. Initial results suggest using multimodal text sets have a positive impact on students' ability to engage in argumentative writing and have a positive impact on teacher practices.

TABLE #16

Revisiting the Impacts of Science Research Experiences: A Critical Review of RETs, CUREs, and UREs

Sanlyn Buxner, University Of Arizona
Jessica S. Krim, Southern Illinois University Edwardsville
Laleh Cote, University of California, Berkeley
Renee S. Schwartz, Georgia State University
Elisa Stone, University of California, Berkeley
Jessica Cleeves, The University of Utah
Lawrence Horvath, San Francisco State University
John Keller, University of Colorado
SoonChun Lee, Wichita State University
Bryan M. Rebar, University of Oregon

ABSTRACT

Research experiences for teachers are popular ways to engage teachers in authentic research with the intention of increasing teachers' knowledge of how science is done and to lead to greater engagement of students in science and engineering practices. Prior literature, including several reviews, has provided details on different program models, benefits and challenges and have called for ongoing examination of program elements, assessment, and outcomes. We report the results of a comprehensive review of 177 empirical papers published between 2007-2017 that include relevant Course-based Undergraduate Research Experiences (CURE), Undergraduate Research Experiences (URE), and Research Experiences for Teachers (RET). Our analysis was based on a research-supported conceptual model of science research experiences and included a review of participant demographics, theoretical frameworks, data collection methods, and reported outcomes. Our findings showed that overall there is a lack of studies explicitly targeting participation and outcomes related to learners from underrepresented populations, few studies that are guided by theoretical frameworks, a small percentage of RETs that focus on translating research experiences into K-12 instructional practices, and a lack of research on the impact on K-12 classrooms. This work is informing the revision of a common assessment being piloted with five RET programs as well as a new classroom observation protocol.

TABLE #16

Professional Learning for Leadership Development: Potential Impacts on Science Leadership Practices

Katy Nilsen, WestEd
Joshua Valcarcel, WestEd
Ashley Iveland, WestEd

ABSTRACT

Researchers studied teacher leadership in a large-scale initiative providing opportunities for teachers to develop understanding of and gain experience with the shifts in pedagogy required by the NGSS. A small cohort of teachers first gained knowledge of the standards and were provided deep experiences in teaching them. But the initiative further tasked these teachers with helping others with NGSS implementation at their schools and districts, and provided professional learning explicitly on leadership. Because instruction aligned with the NGSS is a substantial cultural and pedagogical shift, researchers created a survey to investigate different types of situations where teacher leaders engaged in NGSS implementation leadership. Because researchers sought to examine factors behind teacher leaders' self-reported science leadership practices, they conducted an exploratory factor analysis (EFA) on fifteen science leadership survey items (N=368). After removing cross-loading and low loading items and re-running the EFA, researchers found that the remaining twelve items did indeed cluster around district-level and site-based leadership practices. That is, the EFA revealed a two-factor structure where the latent constructs were named District and School. Further study will include conducting a confirmatory factor analysis (CFA) and triangulating these data with qualitative data being obtained about teachers' leadership.

TABLE #16

Multi-Year Study of Science Teachers PD through Classroom Observation.

Hiya M. Almazroa, Princess Nourah Bint Abdulrahman University (PNU)
Fahad S Al-Shaya, University Of Pittsburgh
Eman M Alrwythy, Alemam Mohammed Bin Saud University

ABSTRACT

The main purpose of this research is to identify the needs of the professional development of teachers in light of the evaluation of their teaching practices through direct observation. It is a descriptive study, (838) classroom observations were conducted during three years. Researchers followed a set of steps to build a context based observation instrument (Saudi Teaching Observation Protocol) (STOP). Results reveals an improvement in science teaching practices in the third year to reach a middle level in comparison with the first year and the second year, which achieved low levels. It can be noted that there is two tenants in the observation instrument maintained their order and significance in the need for development during the three years of the study. These two tenants are: technology use and the science integration with technology, society, and other subjects. Regarding variables related to science teaching, t- test showed significant differences between male and female teachers in favor of women teachers, and T-test shows no significant difference between elementary and intermediate school science teaching.

TABLE #17

Teacher Beliefs and Practice within the Context of an Intensive Teacher STEM Professional Development

Elizabeth L Adams, Southern Methodist University
Tryna Knox, Southern Methodist University
Cassandra Hatfield, Southern Methodist University
Leanne R. Ketterlin-Geller, Southern Methodist University

ABSTRACT

The STEM Academy for Science Teachers and Leaders is an intensive professional development including summer training and frequent coaching. We examine change across in participating teachers' STEM beliefs and enacted instruction (n=37) during the 2018-19 school year. Overall, change in STEM beliefs and instruction was negligible, with small, but statistically significant increases in teacher confidence ($p<.05$) and decreases in teacher perceived importance of STEM ($p<.01$). Based on teacher interviews with teachers who demonstrated higher than average beliefs and instruction, teachers identified several factors that influence PD's role in changing teacher beliefs and instruction.

TABLE #17

Examining Teacher Leadership as a Model for Improvement in Science Education

Sheree Wilson, University of Mississippi
Brooke A. Whitworth, University of Mississippi
Shelby A. Watson – University of Mississippi

ABSTRACT

The current mixed method treatment-control study examined a Teacher Leadership Professional Development (PD) model to determine to what extent treatment teachers had changes in content knowledge, pedagogical content knowledge, practices, and leadership skill and knowledge. The purpose was to determine if this model could create a sustainable model for improving science education in the districts where we worked by utilizing teacher leaders to effect changes in their classrooms and at the school level. Participants included 68 K-8 treatment teachers and 73 K-8 control teachers. Surveys, content knowledge and pedagogical content knowledge assessments, lessons, observations, and artifacts were analyzed using a-priori coding and descriptive and ANCOVA statistics. Results suggest that treatment teachers had statistically significant gains over control groups in content knowledge, pedagogical content knowledge, practices, teacher leadership skills and knowledge. The findings from this mixed methods study will contribute to the understanding of PD and the under-examined field of teacher leadership literature.

Strand 9: Reflective Practice

Strand 9 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #1

Development of a Questionnaire on Teachers' Knowledge of Argument as an Epistemic Tool

William E. Hansen, University of Iowa
Jihyun Hwang,
Chenchen Ding, The University of Iowa
Jee Kyung Suh, University of Alabama
Brian M. Hand, University Of Iowa

Gavin W. Fulmer, University Of Iowa

ABSTRACT
The purpose of this study is to develop an instrument measuring teachers' understanding about argument as an epistemic tool in science classrooms. An ongoing process of domain analysis, item writing, expert review, teacher feedback, item piloting, and item selection. The researchers created an initial survey including 20 items on a five-point Likert scale. To ensure evidence for a structural aspect of validity, Rasch modeling analysis, particularly with the partial credit model, was applied to data of 158 pre- and in-service teachers. As a result of Rasch modeling, the researchers revised the instrument with 10 items without loss of measurement information.

TABLE #18
Evaluating Intercultural STEAM Program in Australia-Korea Contexts: Teachers' Attitudes and Beliefs towards STEAM
Hye-Eun Chu, Macquarie University
Sonya N. Martin, Seoul National University

ABSTRACT
This study was to evaluate a newly developed intercultural STEAM program with students from both Australia and South Korea in upper level primary and lower level secondary science classrooms. The focus of the Intercultural STEAM Program (ISP) is to integrate aspects of STEM, culture, and the arts through four modules designed to integrate these components using an interdisciplinary approach in teaching and learning science. Five teachers were interviewed to ascertain their beliefs and attitudes toward the development and implementation of the ISP in their science classrooms. Their positive and negative beliefs and attitudes were analyzed according to 1) interdisciplinary approaches and integration of the arts and cultural elements in STEM/STEAM-based science teaching, and 2) classroom practices and its impact on students' science learning. The findings indicate that some of the ISP modules have closer integrations between science, the arts, and intercultural perspectives while others were more difficult to develop. Teacher participants expressed positive attitudes and beliefs related to the ease of the ISP implementation, their understanding of the integration of culture and the arts in science, and students' active engagement in their learning of science.

TABLE #18
Fiction, Faction and Action : A pedagogic fusion to teaching science.
Deb J. McGregor, Oxford Brookes University

ABSTRACT
The success of fusing a storytelling approach and inquiry-based science education (IBSE) to teach science is unclear. A few case studies provide illuminatory insights illustrating how 'stories' can be useful to teach scientific concepts, but not accompanied by practical experiences. Studies of practical work suggest the prevalence of 'recipe' style rather than IBSE approaches are commonplace, and with younger pupils teachers focus more support to understand specialist words rather than scientific concepts. This study, consequently, explored the usefulness of combining storytelling with inquiry-based practical work. The research approach was quasi-experimental contrasting the extent to which storytelling and inquiry impact of science learning. Within class groups of children (ages 5, 6 and 10) were organised to enable comparisons of three forms of pedagogy. This also facilitated examination of talk and interaction between year groups. The lessons were video-recorded, transcribed and analysed by applying multiple theoretical frameworks to ascertain the nature and extent of learning about gravity

and forces (the focus of the teaching). One pedagogical approach adopted a storied version of Newton's life as a boy exploring his local environment and illustrated his ideas about forces and gravity through experiments, followed by some hands-on free play. The second approach involved directly describing Newton's scientific discoveries supplemented by the same teacher demonstrations followed by some hands-on free play. The third approach allowed children the unfettered freedom to choose how they might play or experiment with the same apparatus. Hermeneutic analysis illuminated the nature of emergent talk, thinking and learning during the hands-on free play, given differentiated teacher inputs. Whilst there was variation in the nature of the talk across all groups it appeared to be predominantly cumulative. The ways in which apparatus was handled varied between the groups and there were some distinctive differences in questioning and exploratory talk between the groups.

TABLE #18

Lived Experiences of Secondary Science Teachers: Grounding Science Education in the Host Culture and Place

Sheri Fitzgerald, University of Hawaii at Manoa

ABSTRACT

This research documents the lives of six science teachers whose multifaceted identities were influenced over time by Hawaiʻi's unique sociocultural and biogeographical factors. Narrative inquiry was utilized through individual interviews which spanned a five-year period. From restorying, identity narratives and maps were co-constructed and unique eco-identities emerged from these science teachers' lived experiences. The process of coming to know what an eco-identity looks like and why it matters unfolded through constructivist grounded theory methodology. The common threads, or narratives, characterizing eco-identity development and shaping as situated in sociocultural and biogeographical contexts of Hawaiʻi were: (a) reflective environmentalism, (b) an evolving science teacher community of practice, (c) bridging knowledge systems, and (d) island biogeography. The grounded theory suggests a dynamic and multifaceted eco-identity situated in Hawaiʻi, supporting teachers with navigating the professional landscape and reaffirming one's calling as a science teacher. Biophilia, Hawaiʻi sense of place, ʻike Hawaiʻi, and a mindset of "thinking like an island" revealed eco-identity to be the meaning making processes for teachers negotiating their professional and personal lives. Further study on science teacher eco-identity is needed to better understand how such an awareness can impact teacher practices, curriculum development, and teacher education programs in science.

Strand 10: Curriculum, Evaluation, and Assessment

Strand 10 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #19

Integrated STEM+ Computational Thinking Curriculum: Developments in an Underrepresented Community After-school Program for Girls

Henriette D. Burns, Washington State University
Samantha Murphy, Southern Illinois University Edwardsville
Matt Johnson, SIUE STEM Center
Georgia Bracey, Southern Illinois University - Edwardsville
Mark McKenney, Southern Illinois University Edwardsville
Ann Vogel, iBio Institute

Sharon Locke, Southern Illinois University Edwardsville

ABSTRACT
This NSF supported research on a STEM + computational thinking integrated curriculum is a joint effort amongst a local community center, an educational research institute and a STEM center at a Midwest university. The goal for the program is to inspire, motivate and bolster elementary-aged minority girls' STEM and CT abilities and perceptions. The educational research institute's STEM-for-girls' lessons are project-based units on real-life global issues. The first two units were feeding and healing the world with CT content and activities integrated into the lessons. The first-year results of this exploratory study's qualitative observations, select student pre- and follow-up interviews, and quantitative engagement surveys suggest students enjoy the class, better understand both basic computational thinking skills and science, communicate better, and appear to have a broader STEM career interest. However, accepting failure as critical to STEM learning may be a paradigm requiring change. A better understanding of what CT is, how to recognize it, and how to teach it may be fundamental to its integration.

TABLE #19
Developing Thai Students' Understanding of Light and Color Using Formative Assessment and 6E Learning Cycle: Rasch Analysis
Pongprapan Pongsophon, Kasetsart University
Chatree Faikhamta, Kasetsart University
Jeerawan Ketsing, Kasetsart University
Chun-Yen Chang, National Taiwan Normal University
Peiling Lin, National Taiwan Normal University

ABSTRACT
This study aims to examine lower secondary Thai students' conceptual development of light and color after engaging a 3-hour intensive STEM workshop entitled Basic Electrical Engineering and Application of Technology for Science learning in CCR (BEATS-CRR). The students (n=80) were from two secondary schools in Bangkok. The workshop employed formative assessment embedded in 6E learning Cycle instructional model for integrated STEM teaching. In each step of 6E, the students were probed their prior conceptual or procedural understanding, facilitated to do a collaborative task to learn and evaluated their learning using CCR assessment technology in which the teachers could assess students' learning real time enabling highly responsive and adaptive instruction. To measure the learning gains, the students were evaluated their understanding before and after the workshop by a multiple-choice test. The Rasch analysis were employed to estimate item and person parameters. Pre- and post- item difficulty were fixed, post-instruction person ability was estimated, and the means of pre- and post-instruction person ability were compared using Welch t-test. We found the gain was statistically significant ($p < 0.01$). This study discusses pedagogical implication on integrated STEM teaching and coherent assessment system.

TABLE #19
Rethinking the Impact of Inquiry-based Instruction on Student Achievement: Evidence from PISA 2015
Sara J. Dozier, Stanford University

ABSTRACT
Does inquiry-based science instruction, for example using laboratory experiments and scientific argumentation, lead to student learning? Numerous classroom-based studies have shown that these practices are effective. However, other studies, including reports from the influential Programme for

International Student Assessment (PISA), claim that these practices are related to lower student achievement. This study untangles the relationship between PISA student scores and inquiry-based instruction in the United States. PISA reports assume a linear relationship between student-reported frequencies of inquiry-based instruction and achievement (i.e., if a practice is effective, more is better). However, this study shows that a curvilinear model better fits the data. Implications of these findings for practitioners and policymakers is discussed.

Strand 11: Cultural, Social, and Gender Issues

Strand 11 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #20

"Big Ole Geeks": a discourse of Black female representation in STEM media

Raven Baxter, University at Buffalo

ABSTRACT

"Big Ole Geeks" is a catchy new song from Smart Girls Go Stupid, a science-inspired rap album by Raven the Science Maven. The song and music video for "Big Ole Geeks" comments on intelligence, sexiness, inclusion, sand—of course—science. The viral spread of "Big Ole Geeks" across social media provides a unique opportunity to investigate conversations and critiques about the presence of a Black female in STEM engaging in hip-hop culture while enthusiastically promoting an alternative to the eurocentric Western science culture standard. This study is a qualitative critical analysis of public online discourse following the release of the video online. Preliminary data shows demand for a lead Black female character in STEM digital media.

TABLE #21

Case Studies of High School Biology Science Teachers' Experiences Teaching about Race and Racism

Bhaskar Upadhyay, Uniersity of Minnesota

ABSTRACT

In this qualitative multicase study paper, I explored: What influences teachers' pedagogical decisions in teaching about race and racism?. Two biology teachers in two urban school systems were observed over six months as they taught various science units and made pedagogical decisions about inclusion or exclusion of race. The teachers were interviewed three times over the six months period. The data were analyzed qualitatively in an iterative process and the themes were generated based on prior literature review and what came out of the analysis. The findings suggest that teachers' personal racial experiences influence pedagogies that teachers choose about race and racism while teaching. Additionally, teachers also make decisions about addressing racism in science teaching based on the topics and communities in which students live. Student experiences also shape how racism is discussed in science classes.

TABLE #21

Exploring the Lived Experiences and Narratives of the African American Gullah Geechee Peoples to Create Culturally Relevant STEM Curriculum.

Catherine Quinlan, Howard University, School of Education

ABSTRACT

This presentation is part of a larger federally funded NSF grant project to include the narratives and lived experiences of African Americans in the STEM curriculum. This presentation explores the lived experiences, historical context, and culture of the Gullah Geechee peoples of South Carolina. The findings show that embedded within the history and plight of the Gullah Geechee peoples are their roles in bringing innovative agronomic – science and technology – implementations that have paved the way for new irrigation methods that have contributed to our current economic advancement within the United States. A role for examining the chemistry, physics, and technology methods along with environmental sustainability concepts is implicated. This research has implications for adding to the science capital and to culturally representative STEM curriculum for African Americans. Please note the views of this presentation does not necessarily reflect the funding agency, NSF.

TABLE #24

Factors influencing Biology majors' persistence in their degree

Jennifer L Idema, Texas State University
Kristy L. Daniel, Texas State University
Shetay Ashford, Texas State University
Dana Garcia, Texas State University

ABSTRACT

In effort to promote diversity within the STEM workforce, we must first identify factors that influence and/or hinder underrepresented, minority student persistence within STEM degrees. We documented potential influential factors in student persistence in STEM degrees to create a 14-item Likert scale instrument. We recruited 137 undergraduate biology majors at a Hispanic Serving Institution in Texas to report which factors they found influential in their decision to remain enrolled in their degree program. We used a modified social cognitive career theory model of career choice to guide interpretation of the reported influences and identify patterns in responses. We documented three highly influential factors for all students: Personal Motivation, Potential Learning Experiences, and Job Opportunities. With the later showing a significant difference (P=0.036) between White and Underrepresented student groups. While only approaching significance (P = 0.056), we also found that White students were more influenced by Role Models/Mentors than underrepresented students. Our findings suggest that personal drive and potential job opportunities are the strongest influential factors driving students into seeking educational opportunities leading STEM careers. However, access to a diverse pool of role models also has the potential to provide positive impacts on student persistence in STEM.

TABLE #22

Noticing whiteness in science education: Using critical whiteness scholarship to achieve equity in science

Jonathan D. McCausland, The Pennsylvania State University

ABSTRACT

For over two decades, policies and reforms have been geared towards increased representation of marginalized groups in science. Unfortunately, studies still document the lack of recognition and access students of Color experience in science learning contexts. One reason for this continued trend may be

the overwhelming presence of whiteness in science and science education. In order to understand how whiteness exists within science education's articulation of the nature and culture of science as well as equitable science teaching for students and teachers, this article brings critical whiteness scholarship to bear. By unpacking critical whiteness scholarship in relation to science education literature and demonstrating its value by analyzing two powerful works of scholarship by Braaten and Sheth (2017) and Sheth (2019), this proposal constructs an argument that advocates for a new focus on whiteness in science education scholarship. Through analyzing science education scholarship using critical whiteness studies, suggestions for how critical whiteness studies can support work already being done in service of students of Color in science and outlining potential directions for research that support this line of thinking.

TABLE #22

On being a person of color in a STEM graduate program: Experiences of assimilating into the culture of science

Renee S. Schwartz, Georgia State University
Megan Grunert Kowalske, Western Michigan University

ABSTRACT

This research focuses on the experiences of underrepresented minority/ized (URM) students in Science, Technology, Engineering, and Mathematics [STEM] graduate education. This paper is part of a 3-year longitudinal mixed methods study to trace the experiences of URM graduate students to understand their negotiation of multiple, and often conflicting, identities as they progress through their graduate programs. Using lenses of science identity, situated learning, and community of practice, this paper focuses on experiences related to how students of color assimilate into their graduate programs and their respective community of researchers. The context for this study is STEM graduate programs at three large, primarily white institutions in the US. The research questions are: (1) What experiences do URM graduate students report as influential to their assimilation, or sense of belonging, into a STEM graduate program? (2) What experiences do URM graduate students report as influential to their assimilation, or sense of STEM identity, as a researcher in a STEM field? Results suggest that positive recognition from faculty, peers, and members of the broader STEM communities directly influence students' assimilation into their programs and their STEM identities. Students of color in these programs also experience assimilation challenges associated with racial and cultural identities.

TABLE #22

Race-Oriented Lectures Study: Racial Socialization and Bias Preparation for Black Students

Henry Hane, Indiana University - Purdue University Indianapolis
Jomo W. Mutegi, Indiana University, IUPUI
Lance Howard, Indiana University

ABSTRACT

Clark, Anderson, Clark, and Williams (1999) write that "racism is operationally defined as beliefs, attitudes, institutional arrangements, and acts that tend to denigrate individuals or groups because of phenotypic characteristics or ethnic group affiliation" (p. 805). Given the pervasiveness of racism in our modern "post-racial" society, it is reasonable to assume that students of African descent who matriculate through American science classes are very likely to encounter racism not only in society at large, but also their specific educational environments.There is good evidence that one manifestation of racism is educational regress. Empirical studies of stereotype threat (McGee, 2018), microaggressions (Keels, Durkee & Hope, 2017; Mutegi, Sorge, Fore & Gibau, in press), and teacher expectations (Prime &

Miranda, 2006), provide just a few examples. The focus of the study is to explore the impact of race-oriented community lectures on students' racial identity development. The rationale for the study derives from social psychological findings that suggest that we are heavily influenced by how we are socialized. The theoretical framework for the study is a part of a call for further conscientization, and therefore, improvement to the STEM field. Our findings indicate there such lectures affect students ethnic identity affirmation positively.

TABLE #23

STEM Faculty Efforts in Pedagogical Innovations: An Example in Biology

Melo-Jean Yap, San Diego State University
Felisha Herrera, San Diego State University

ABSTRACT

Brownell & Tanner (2012) identified a prevailing culture that "deemphasizes teaching specifically to maintain high professional status" among STEM faculty members. Despite these seemingly negative values towards pedagogy, a complex professional terrain such as the STEM fields comprise of heterogeneous attitudes toward innovating classroom praxis that promotes diversity, inclusion, and equity. This paper highlights a paradigm shift in this culture regarding pedagogy: through the theoretical lens of situational learning, we examine the communities of practice (CoP) of Biology professors in the context of participating in pedagogical innovations. In-depth qualitative narratives were collected from a national sample of 40 Introductory College Biology instructors from across the United States who engage in collective and individual efforts towards pedagogical innovations. Findings show that faculty collaborate and solve class issues together. They also incorporate active learning strategies and technological tools towards equitable pedagogical practices in promoting student learning. However, challenges abound in such efforts, such time constraints of executing active learning strategies versus covering content and acknowledging underrepresentation as an issue. These findings reveal a paradigm-shift in individual and institutional attitudes towards pedagogical innovations in Biology education. Innovative-minded NARST members may benefit from knowledge of dynamic CoPs in addressing broadening participation in the STEM fields.

TABLE #21

The role of indigenous knowledge in enhancing science concept formation through inquiry-based learning

Umesh Ramnarain, University Of Johannesburg

ABSTRACT

This theoretical paper explores the role and value of indigenous knowledge in enhancing science learning through inquiry-based learning by drawing on the framework of Embodied, Situated, and Distributed Cognition (ESDC). Indigenous knowledge of learners has often been marginalised in the science classroom due to teachers lacking in pedagogical knowledge on how indigenous knowledge can be infused into the science classroom, and due to a perceived tension between the indigenous and scientific worldviews. Insights from the over-arching tenet of ESDC, are that cognition is physiologically embodied, socio-culturally situated, and ostensibly distributed among individuals. An extensive review of literature on the relationship between and indigenous worldview and a scientific worldview, does identify key aspects that align with the ESDC and that have significance for classroom practice. In particular, an inquiry-based approach in enabling learners investigate ideas emanating from indigenous worldview, and the role of argumentation in promoting a discourse that supports learners straddling across the two worldviews are discussed.

TABLE #23

Translanguaging with Three Languages and Multimodal Interactions: English Learners' Science Experiences at a STEM-Focused School

Jennifer Tripp, University at Buffalo
Noemi Waight, University at Buffalo

ABSTRACT

This naturalistic, exploratory case study examined the experiences of ninth grade English Learners (ELs) from diverse racial, ethnic, and linguistic backgrounds in an urban inclusive STEM-focused high school (ISHS). Data included student interviews, field notes, and video recordings from classroom observations. Findings revealed that an affirming classroom context encouraged ELs to share ideas with peers and question their understanding. In addition, there were opportunities for ELs to engage in hands-on, multimodal instruction. These components of the classroom environment and instruction were foundational for ELs who shared the added burden of navigating across their home language, various registers of English, and an additional language—the language of science. This challenge was clear as students revealed tensions navigating instruction and state assessments in English. Altogether, the findings have implications for (a) examining tensions of students' (especially ELs') past science experiences and how these experiences impact their current school science experiences; (b) the critical role of teachers in fostering supportive, open learning environments that allow ELs to confidently engage with their learning through multiple modes; and (c) the importance of equitable assessment design and supports for ELs to represent their science disciplinary understandings over linguistic accuracy.

TABLE #24

Urban STEM Education Successes in the Bronx: Moving Away from the Deficit Model

Judith Gouraige, NYCDOE and Stony Brook University

ABSTRACT

Urban STEM Education Successes in the Bronx: Moving Away from the Deficit Model   In this case study, the deficit model is turned around by examining 4 successful Bronx high schools. The schools have a science, technology, engineering and math (STEM) focus and their characteristics are compared in terms of educational philosophy and practical operational decisions as a possible guide for urban STEM success. The study identified themes based on pedagogical and structural choices they have made in creating school course offerings, hiring and developing teachers and support personnel, how they organize and schedule students into courses and how they support students within the school. Findings highlighted the type of supports for struggling students, creating a culture of expected achievement and inter staff relationships, especially collegiality ad new teacher professional development as key factors in success.

TABLE #24

Words Matter: A Queer Theory Analysis of Anatomy/Physiology Textbooks

Harshini Sirvisetty, University of Louisville
Katherine E. Ray King, University of Louisville
Linda C. Fuselier, University of Louisville

ABSTRACT
Biology is unique from other science disciplines in that concepts taught in core classes can inform our student's understanding of sex and gender. Biology majors encounter lessons on sex determination, sexual reproduction, sex characteristics, and sexual selection in their introductory and upper-level courses. The language in these units matters. In recognition of the influence textbooks have in classroom discourse and the act of learning science, we performed a qualitative close read of human anatomy/physiology textbooks grounded in queer theory. We selected undergraduate textbooks used by universities with top ranked nursing programs. Two researchers agreed on topics and identified textbook content. All textbooks we examined showed examples of each of the categories that we originally identified as hindering inclusivity of gender-diverse populations. These problematic patterns suggest room for improvement in the uptake of new knowledge about sex/gender/sexuality and considerations of inclusivity. As part of Strand 11. Cultural, Social, and Gender Issues, this textbook analysis aligns with the equity and social justice considerations that lead educators to see the ways that the repeated Othering and perpetuation of social norms as scientifically validated alienates our LGBTQ+ students.

Strand 12: Educational Technology

Strand 12 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #25

Textbook and Virtual Reality as a Means to Promote Scientific Writing

Richard Lamb, East Carolina University
Jing Lin, Beijing Normal University
Brian M. Hand, University Of Iowa
Amanda Kavner, University at Buffalo
Douglas Hoston, University at Buffalo

ABSTRACT
As neuroscience gains attention in the wider popular imagination, one must ask about the impact and influence of these domains on fields such as science education. The emerging field of Educational Neuroscience brings together members of multiple communities who are interested in exploring and understanding how learning and education occur in the science classroom. The measurement of specific cognitive dynamics in individual students is critical for understanding the role of cognition and brain function as it relates to the process of learning in the science classroom. Recently, VR applications have received considerable popular attention as a new medium for providing alternative experiences (to textbooks) in the classroom. The purpose of this study was to investigate the role textbooks can play on writing complexity and lexical density as a proxy for learning, in relation to argumentative and summative writing when integrated with a virtual reality experience. This study aimed to show and compare the effects of VR on writing with four conditions. 100 college aged participants and identified localized hemodynamic activations in the prefrontal cortex using fNIRS as they engaged in undertaking these two writing tasks. The main effect of the learning condition was statistically significant.

TABLE #25

Engineering Students Perceived Innovative Thinking and Actual Innovation in Face-to-Face and Online Settings

Maya Usher, Technion
Miri I. Barak, Technion - Israel Institute Of Technology

ABSTRACT

Innovation is a key factor for growth and success in the 21st century, and hence, a vital competency for engineering students. Research in engineering education attaches great importance to the understanding of students innovative thinking and the innovation level of their learning outcome. Yet, studies on innovation cultivation and the connection between perceived and actual innovation are scarce. Moreover, the recent trend of developing engineering courses in online platforms (e.g., Coursera, edX, etc.) raises the need to examine students' innovation capabilities in digital learning environments. Hence, the goal of this study was to examine engineering students perceived innovative thinking and its interrelationship with actual innovation, in face-to-face and online settings. The study was conducted in the setting of a course in nanotechnology, while comparing between three groups: face-to-face (F2F) university students, online university students, and massive open online course (MOOC) learners. Applying the quasi-experimental design, data were collected via an online questionnaire and the grading of students' learning outcomes. Findings indicated that the MOOC learners reported behaviors that are more compatible with innovative thinkers, compared with both groups of university students. Results further pointed to students' limited calibration between their perceived innovative thinking and actual innovation in team projects.

TABLE #25

Supporting Chemistry Learning through Augmented-Reality – A Glimpse on Usability and Cognitive Load

Sebastian Keller, Universtiy of Duisburg-Essen
Sebastian Habig, University Of Duisburg-Essen
Stefan Rumann, University Of Duisburg-Essen

ABSTRACT

Augmented reality seems to be a promising way to get over a representation dilemma during learning organic chemistry and to foster students´ understanding. By translating two-dimensional printed illustrations into three-dimensional models, it is supposed that the extraneous load during the learning process can be reduced and so the students can effort a larger amount of working memory capacity for the elaboration of important concepts. However, even the layout and performance of the Augmented Reality itself can be disruptive and could increase the extraneous load. Based on research literature a paper-based learning material for organic chemistry and also an Augmented Reality App were developed, considering design principles of multimedia learning. Especially the usability of and the learners experience with the Augmented Reality App were investigated in a mixed-method study. First results indicate a nearly excellent usability of the App and low levels of extraneous load induced by the material.

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

Strand 13 Roundtable Session

3:45 PM-4:45 PM, Exhibit Hall

TABLE #26
Analyzing Science Education as a "Construction Site for Science" using Latour's Collective of Humans and Non-Humans
Donald J. Wink, University of Illinois at Chicago

ABSTRACT
The development of science education has made significant use of perspectives from the philosophy of science that emphasize realism, where science and science education develop understanding of the world as it (really) is, and constructivist perspectives, where science and science education develop understandings that fit within the (constructed) reality of the discipline or the learner. These represent two opposing perspectives. But intermediate positions have emerged. Bruno Latour contributed significantly to discourse-oriented social constructivist views of science in early contributions. But since the late 1990's, especially in Pandora's Hope and The Politics of Nature, he adopted the perspective of seeing science as a "collective of humans and non-humans". This poster paper will document examples of how this post-constructivist perspective also reformulates understanding of the nature of classroom education and an understanding of the community that engages in constructing knowledge. The paper includes research in the context of examining artifacts and reflective reports from a comprehensive high school curriculum and professional development project, constituting science education as a form of a "construction site for science" for the use of Latour's framework. It also has a theoretical component, exploring a novel framework for considering the classroom and linking to other post-constructivist perspectives.

TABLE #26
Visualizing Connections between Nature of Science and Engineering
Jeffrey Radloff, SUNY Cortland
Brenda Capobianco, Purdue University

ABSTRACT
National science reform presents science with engineering as a set of shared ideas, practices, and cross-cutting concepts and recommends the use of engineering design-based science instruction, both drastic shifts from previous standards. While the presence of a standardized nature of science (NOS) supports the inclusion and interpretation of shared science practices, however, the nature of engineering (NOE) is markedly absent. The purpose of this theoretical poster presentation is to promote the increased legitimization of engineering in science contexts and support the development and refinement of K-12 science educators' NOS and NOE understandings by visually representing relationships between these constructs. We illustrate and analyze multiple perspectives on science and engineering supported by literature, from being two wholly separate disciplines to completely overlapping, each with unique implications for science education research, teaching, and learning. Notably, they all depict ways that NOS/NOE may be understood by practicing science educators. As such, the synthesis of visual conceptions represents a practical way of identifying and characterizing NOS/NOE connections and offers science teacher educators and researchers entry points to further investigate both natures (NOS, NOE), including their eventual interpretation and uptake by science educators.

TABLE #26
Evidence and rationale for expanding The Views of Nature of Science Questionnaire
Ryan Summers, University of North Dakota
Fouad Abd-El-Khalick, University Of North Carolina At Chapel Hill

Jeanne Brunner, University of Massachusetts Amherst

ABSTRACT
In an attempt to understand nature of science (NOS) conceptions held by learners in greater detail, researchers have steadily become more reliant on open-ended measures. The Views of Science Questionnaire (VNOS) is the most frequently used open-ended instrument. Conceptually grounded in many of the same aspects emphasized in the Next Generation Science Standards, the VNOS-C is appropriate for capturing the views of secondary school students and adults along 10 dimensions related to NOS. However, it has been observed that the 10-item VNOS-C seems to have difficulty uncovering some particular NOS aspects, or rather respondents may need additional prompting. Two new items have been developed and administered to expand the VNOS instrument (VNOS-CE). The present study focuses on evaluating whether these items function as intended, soliciting responses for the target NOS aspects, and whether these contributions add value to the instrument as a whole. Data comes from 37 pre- and in-service elementary, middle and secondary teachers. Results suggest one of the items adds considerable breadth, eliciting responses from multiple NOS aspects, while the other adds much needed depth related to one aspect, social NOS. Implications for the field and assessment of NOS are discussed.

TABLE #17
Using Children's literature in the Middle School Science Class to Teach Nature of Science: Preservice Teachers' Development of Sources
Banu Avsar Erumit, Recep Tayyip Erdogan University
Valarie L. Akerson, Indiana University

ABSTRACT
In this study, we report the results of the descriptive analysis of preservice middle school science teachers' own written story books and related lesson plans that includes the science content (science units and science topics), target grade, and main characters used in the book. We also report the results of content analysis of story books in terms of their accurate and explicit representation of nature of science aspects and cultural perspectives identified in the books. Also, we report the analysis of audio recorded classroom discussion with six grade students about five of these story. The participants of this study were 49 pre-service middle school science teachers taking nature and the history of science course, and 13 six grade students. The 49 books and lesson plans covered a range of content areas. While 27 PSTs preferred to use popular main characters in their stories, 22 PSTs did not use any popular characters in their stories. Among the NOS aspects, observation and inference was the most commonly used aspect that was followed by tentativeness. Some books explicitly represent the culture where they were created such as a traditional food or a famous historical figure.

Strand 14: Environmental Education
Strand 14 Roundtable Session
3:45 PM-4:45 PM, Exhibit Hall

TABLE #13
Arts Integrated Environmental Education Professional Development
Lauren Madden, The College of New Jersey
Louise Ammentorp, The College of New Jersey
Carolina Blatt, The College of New Jersey

Dana Kneis, Ridgewood High School

ABSTRACT
In this study, 26 pK-8 teachers from six schools participated in a comprehensive and interdisciplinary professional development (PD) effort focused on integrating environmental education across the curriculum. One focus of the PD was using an arts-integration, and participants engaged in multiple examples of arts-based activities. These activities used arts-integration for four purposes: communication, creative expression, content explanation, and community building. We used a qualitative approach to analyze the degree to which teachers shifted instruction to include arts-integration or planned to make shifts in the future. Data sources included post-PD surveys, site visits and observations, and email communication with teachers. We found that arts-based strategies were well received by teachers and were used for each of the four purposes described above. Exemplar findings are provided and will be discussed in our presentation.

Strand 15: Policy
Strand 15 Roundtable Session
3:45 PM-4:45 PM, Exhibit Hall

TABLE #23
STEM Education as a District-Wide Innovation: A Cross-Case Analysis of Three School Districts
Tamara Holmlund, Washington State University Vancouver
Kristin S. Huggins, Washington State University

ABSTRACT
The purpose of this study is to understand the knowledge, skills, and interactions leadership teams from three school districts developed and utilized to enact and support others in enacting STEM learning opportunities in K-12 classrooms across their district. STEM literacy is promoted as developing students' capacity to participate in and contribute to 21stcentury opportunities and challenges. Thus, all students in a school system should have access to meaningful STEM learning opportunities. We developed case studies of the leadership teams in two rural and one suburban school district committed to enacting STEM education for all K-12 students. The results of our cross-case analysis focus on teacher leaders (TLs) and show how the TLs: 1) individual and collectively worked to make sense of STEM so they could help others do the same; 2) learned that to influence their colleagues it was more impactful to work one-to-one and important to accept another's existing beliefs and perception of risk about STEM; and, 3) it was also necessary to enact leadership system-wide to support administrators' understandings and buy-in for STEM and address specific contextual factors. This study contributes to the emerging research base on district-wide enactment of STEM education.

Concurrent Session 6b - Posters
4:45 PM-5:45 PM

Strand 1: Science Learning, Understanding and Conceptual Change
Strand 1 Poster Session
4:45 PM-5:45 PM, Exhibit Hall

P1:

A Review of Empirical Literature: Cognitive Processes Framing Modeling Practices in Science Education

Ayca K. Fackler, The University of Georgia

ABSTRACT

Modeling is still a long way from a complete understanding of the cognitive processes, theories, and frameworks that interact with modeling practices in science education. This review brought together the empirical literature on modeling practices in science education. The study presented a targeted literature review of research focused on modeling practices in line with cognitive concepts, processes, and/or frameworks. The review examined the cognitive processes, theories, and/or frameworks that are used to frame modeling practices in each study and critiqued the nature of the modeling practices. The results from this review revealed that the empirical studies in the modeling literature focus on meta-modeling, reasoning, and schemata (in) learning to frame the modeling instructions in science education.

P2:

Developing and Validating a Learning Progression for Computational Thinking in Earth and Environmental Systems

Beth A. Covitt, University Of Montana - SpectrUM Discovery Area
Kristin L. Gunckel, University Of Arizona
John C. Moore, Colorado State University
Alan R. Berkowitz, Cary Institute of Ecosystem Studies
Bess Caplan, Cary Institute of Ecosystem Studies
Judith A. Cooper-Wagoner, University of Arizona
Michael Jahnke, University of Montana
Daniel L. Moreno, University of Arizona

ABSTRACT

In order to participate effectively in discussions and debates about environmental problems, an informed public needs to be able to access and understand evidence-based arguments that draw on computational models of Earth and environmental systems sciences. In an effort to expand understanding of how students make sense of and learn to engage in computational thinking practices, this poster synthesizes work over the past four years from a project aimed at integrating computational thinking into high school level hydrology instruction. This poster will present project products including (1) a validated learning progression identifying three levels of knowledge and practice associated with computational thinking in hydrologic contexts, and (2) evidence of student learning as a result of engaging in instruction designed with reference to the learning progression upper anchor and responsiveness to students' ways of thinking. Findings show that high school students make sense of computational modeling in hydrologic contexts in increasingly more sophisticated ways spanning from "literal model use," to "procedural model use," to "principle-based model use." Initial analyses of data from students who participated in instructional units informed by our leaning progression research demonstrated significant pre/post learning gains related to making sense of computational models of hydrologic systems.

P3:
Investigating Groundwater: 7th-Grade Students' Mapping Models to Phenomena
Holly White, University of Nebraska-Lincoln
Diane Lally, University of Nebraska-Lincoln
Cory T. Forbes, University Of Nebraska–Lincoln

ABSTRACT
Groundwater is a vital water resource which is increasingly threatened by overconsumption and contamination due to human activities. This makes groundwater a critical component of the global water cycle and standards-based topic within science education. However, many students hold alternative ideas about groundwater or limited awareness of groundwater systems. One way to support students' learning about groundwater is through the use of data-driven, computer-based modeling tools. Here, we report findings from a study conducted in 7th-grade classrooms during implementation of a 3-week curriculum module designed around a groundwater modeling tool. Students completed a series of tasks using the modeling tool to reason about and engage in problem-solving about real-world, scenario-based water challenges. Here, we focus on how students understand and interpret elements of the model as they relate to components of the real-world water-related phenomena they investigated. In this study, we conducted quantitative and qualitative analyses of student assignments and interviews. Findings suggest that students could more easily interpret and understand model elements which represent human dimensions of groundwater systems than they could elements which represent natural dimensions and processes. These findings provide important insights into students' model-based reasoning about groundwater and teaching and learning about coupled human-hydrological systems.

P4:
Socio-scientific issues to engage students in claims, evidence and reasoning
Sissy S. Wong, University of Houston
Jie Zhang, University of Houston
Jennifer Donze, University of Houston
Jackie Relyea, North Carolina State University
Ma Glenda Wui, University of Houston

ABSTRACT
Scientific argumentation is important in helping students develop critical thinking skills, reasoning from evidence and problem-solving skills. Unfortunately, science classes often do not include argumentation because teachers are uncomfortable with implementing argumentation or time-constraints prevent argumentation from occuring in science classrooms. To examine how different avenues can increase opportunities for argumentation in science classes, this study examined whether a socio-scientific curriculum that targeted 137 sixth grade students' science content knowledge, academic language, argumentation, and critical thinking skills impacted their ability to state claims, evidence and reasoning when presented with a real world question. A pre-test and post-test was used to determine that experimental and control groups both learned the target content, but the experimental group successfully composed claims and use evidence-based reasoning while the control did not.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Strand 2 Poster Session
4:45 PM-5:45 PM, Exhibit Hall

P5:
Applying Conjecture Mapping to Analyze Children's Use of Science Practices in Story-Driven Investigations

Kyungjin Cho, Pennsylvania State University
Julia Plummer, Pennsylvania State University

ABSTRACT
This study investigates how stories interact with children's use of science practices during museum-based programs. We developed three workshops prompted by a storybook's questions about science phenomenon. Each workshop was implemented and video recorded 3-4 times with children 3-5 years old. We used conjecture mapping as analytic approach to generate conjectures demonstrating how design and theoretical features work together to produce our desired outcomes: evidence-based explanations. Analysis revealed that mediating processes in our conjecture were more strongly influenced by concepts and phenomena from the story than the narrative. The strongest influence of the storybook's narrative on the embodiments was through the design of the story-driven investigation. Story-driven investigations influenced key mediating processes that shaped the opportunities for evidence-based explanations: thematic-mediated discourse, investigating phenomena, and generating representations. Results of this study suggest that educators can use story-driven investigations to design program to support young children's constructing evidence-based explanations; for this purpose, we recommend that educators provide prompts and questions from the storybook narrative, as well as their own prompts and questions based on the central phenomenon in the story, to mediate children and educators' discourse for evidence-based explanations in museum programming.

P6:
Youth Social Interactions in Informal Makerspaces: What are the pedagogical implications for supporting productive collaborations?

Ti'Era D. Worsley, University of North Carolina at Greensboro
Edna Tan, University Of North Carolina At Greensboro
Sara Heredia, The University of North Carolina Greensboro

ABSTRACT
This study looks at the social interactions between African-American youth in an informal STEM makerspace program at their local Boys and Girls Club. We discuss how their partner choices influence the quality of work that is produced. We examine how particular friendship groups open up or truncate learning spaces for youth, and what the design and pedagogical implications are for adult facilitators. In a space where youth have agency, how do we as facilitators intervene when we see their learning/productivity becoming affected by their partner choices? We look specifically at two case studies where we follow the positive and negative effects of their partner choices and how their quality of work is directly impacted. While both partnerships started out positive they began to shift in a negative direction. Within this community space there are many intersecting factors so we apply Cultural-Historical Activity Theory as a guiding framework. Methodological approaches include critical longitudinal ethnography comprised of fieldnotes and interviews focused on youths' partner choice and how the resultant collaborative space impacted their learning experiences, analyzed in the grounded theory approach.

P7:
Children arguing in science lessons over time: the discursive construction of evidence use
Luiz Gustavo Franco Silveira, Universidade Federal de Minas Gerais (Brazil)
Danusa Munford, Universidade Federal de Minas Gerais

ABSTRACT
We investigate how third graders discursively constructed the practice of evidence use during argumentation in science lessons. We followed a group of children over three years since their inclusion in the 1st grade of elementary school. The paper reports on a period of 5 months in the first semester of 3rd grade. The research design was guided by Ethnography in Education. Based on discursive interactions of three events in science lessons, we analyzed variations in the focus of the students' argumentation and different ways data should be interpreted. Over time, aspects related to ways of interpreting phenomena seem relevant to an understanding of how the group made sense of using evidence in science classroom. The analysis indicates possibilities to give greater visibility to contextual aspects of discussions, especially how the different directions of the discussions were related to participant's use of evidence. Regarding the scholarly implications of the study, it contributes to current research that indicates the way people think about processes of construction of knowledge. Become able to support claims with evidence is only part of the learning to use evidence in argumentation and discussions around ways of interpreting data are also essential.

P8:
Design-Based Lessons Foster Equity When Integrating Engineering Into Biology Classrooms
Tory H. Williams, University of Maryland Baltimore County
Christopher R Rakes, University of Maryland Baltimore County
Jonathan Singer, University of Maryland, Baltimore County
Jacqueline Krikorian, University of Maryland Baltimore County
Julie Ross, Virginia Tech

ABSTRACT
The integration of engineering into science education is challenged by limited research-based, engineering instructional materials and aligned teacher preparation. The INSPIRES educative curriculum was developed to infuse engineering ideas into science classrooms through equitable practices. Our study measures students' growth in STEM learning outcomes as a function of the INSPIRES curriculum and PD. Post-assessment scores were analyzed with HLM, accounting for student-specific traits. Students identifying as Black and Hispanic significantly outperformed their White peers on design-focused and knowledge/comprehension-level questions, yet performed disproportionately lower on science-focused and synthesis/evaluation-level questions. Since teachers utilized more reformed pedagogies in design- than science-focused lessons, our findings suggest that reformed, design-based, STEM activities foster equity in science classrooms while 'traditionalizing' inquiry lessons may widen achievement gaps.

P9:
What Does Engagement Look Like? Secondary Science Teachers' Reported Evidence of Student Engagement
Vance J. Kite, North Carolina State University
Michelle Nugent, North Carolina State University
Soonhye Park, North Carolina State University
Roger Azevedo, University of Central Florida

Min Chi, North Carolina State University
Michelle Taub, University of Central Florida

ABSTRACT
A teachers' ability to provide effective instruction is influenced by their ability to gather in-the-moment data from their students to inform rapid, instructional adjustments. Student engagement is a multifaceted construct consisting of behavioral, emotional, and cognitive dimensions, and is one of the most prominent data-streams used by teachers to inform instruction. However, very little is known about what teachers count as evidence of student engagement and whether or not these evidences connect to student learning. We conducted a survey study to build an understanding of what secondary science teachers report as evidence of student engagement. 115 surveys were completed and 897 individual pieces of evidence were included in our analysis. Our results indicate that 1) teachers primarily attend to behavioral markers of student engagement (particularly as evidence of student disengagement), 2) Asking relevant questions is the most-frequently reported form of evidence, and 3) the top evidences of positive engagement included all components of engagement (behavioral, emotional, and cognitive) while the top evidences of disengagement were all behavioral. Our work extends the few studies on teachers' perceptions of student engagement and provides important insights for the development of initiatives to attune teachers to the most important aspects of student engagement.

P10:
Examining The Integration Of Science And Engineering: The Stickiness Of Tinkering In An Elementary Classroom
Jennifer Schellinger, FSU
Lama Jaber, Florida State University
Sherry A. Southerland, Florida State University

ABSTRACT
Science reforms present an integrated approach to science and engineering education in which science is foundational to engineering and engineering contextualizes and reinforces science ideas. This research explores how one elementary school teacher and her students came to understand what is expected of them when asked to engage in an integrated science and engineering unit on simple circuits. The data examined included whole class and small group video recordings and classroom artifacts of a 9-week unit on energy movement in simple circuits in which students engaged in activities to develop skills to build simple circuits and develop explanations of energy movement in a circuit. Analysis of whole class and small group video transcripts and artifacts revealed that an integrated approach may be more problematic that promising for teachers and students. While the teacher framed the task as the integration between science and engineering and pressed students to make sense of the underlying phenomenon, students took up the task as one to tinker with and troubleshoot about materials. We see the work of tinkering to have a true "anchoring effect", causing students to persist in such work, a persistence that worked against the goal of science sensemaking.

P11:

Multifaceted Effects of Self-efficacy on Taiwanese High School Students' Learning Engagement

Tzung-Jin Lin, National Taiwan Normal University

ABSTRACT

In the past, most empirical studies were concerned with the relations between a certain type of learning engagement and one single scale of self-efficacy, without a more comprehensive examination. By analyzing a total of 280 Taiwanese high school students' responses on the two quantitative instruments, the Science Learning Self-Efficacy (SLSE) instrument and the newly-developed Science Learning Engagement Instrument (SLEI), this study aims to differentiate the predictive powers of multi-faceted science learning self-efficacy on assorted forms of science learning engagement. The results indicated that, for Behavioral engagement and Agentic engagement, the SLSE dimensions of Higher-order Cognitive Skills and Practical Work are the positive predictors. Next, the two SLSE dimensions of Everyday Application and Conceptual Understanding can positively predict Cognitive engagement. Similarly, in addition to the SLSE dimensions of Everyday Application and Conceptual Understanding, the SLSE dimension of Science Communication can also positively predict Emotional engagement. Finally, for Social engagement, three SLSE dimensions, Science Communication, Practical Work, and Conceptual Understanding, are the positive predictors. The findings of this study could be informative for science educators and practitioners to adequately engage students in various aspects of science learning.

P12:

Traces of Ambitious Science Teaching and Science and Engineering Practices in Teachers' Noticed Moments of Students' Thinking in a Science Classroom

Sahar Vali, West Virginia University
Melissa J. Luna, West Virginia University

ABSTRACT

In this work, we examined the relationship between science teaching and learning in two elementary classrooms where science-as-practice was supported. Specifically, using a teacher noticinglens, we investigated the relationship between Ambitious Science Teaching (AST) and meaningful student engagement in disciplinary practices. Our results indicate that patterns exist between the AST practices enacted by teachers and the disciplinary practices students engaged in during lesson activities. The patterns and trends we saw in our data (and those we did not but might have expected) are revealing in what they tell us about the different ways AST practices are used (at least by the two teachers in this study) at different times to support meaningful student engagement in different disciplinary practices (and when they are not). This small study begins to scratch the surface in our understanding of this complex relationship. While more research is needed, this study provides necessary insight into this relationship, which helps us as science education researchers and teacher educators better support a science-as-practice vision of reform-based science teaching and learning in elementary classrooms.

P13:

Threshold Concepts in Novices' and Experts' Evolutionary Explanations

Daniela Fiedler, IPN – Leibniz Institute for Science and Mathematics Education
Gena C. Sbeglia, Stony Brook University (SUNY)
Ute Harms, IPN – Leibniz Institute for Science and Mathematics Education
Ross H. Nehm, Stony Brook University (SUNY)

ABSTRACT
A rich body of work has investigated the composition, structure, and coherence of students' evolutionary reasoning by documenting the abundance, frequency, and co-occurrence of key concepts (e.g., variation, differential survival) and naïve ideas (e.g., goal-directed reasoning, use-disuse inheritance) in written explanation tasks differing in situational features. Recent research has emphasized that additional normative concepts (so-called threshold concepts) such as randomness, probability, spatial scale, and temporal scale are also central to robust evolutionary understanding. To date, little work has explored the use of threshold concepts in evolutionary explanations. This study employs a novice-expert framework and content analysis to examine putative differences in novices' and experts' use of threshold concepts in animal gain and plant loss contexts. We administered two ACORNS instrument items to samples of undergraduate and evolution expert participants. Our analyses of the 580 written explanations indicated that experts used more randomness-related concepts in both items compared to novices, whereas the novices used (slightly) more probability and temporal-related concepts than experts. These findings raise important questions about the types of assessment tasks best suited for uncovering novice and expert utilization of threshold concepts in evolutionary reasoning.

P14:
Teaching and Learning in Makerspaces: Equipping Teachers to Become Equity Oriented Maker Educators
Sara C Heredia, The University of North Carolina Greensboro
Edna Tan, University Of North Carolina At Greensboro

ABSTRACT
Making and Makerspaces are becoming increasingly popular in K-16 educational settings and have been put forth as an important space to support minoritized youth to develop STEM identities and a sense of belonging in science. However, the integration of making in educational settings is complicated and requires learning opportunities that support educators to learn about making tools and technologies and a pedagogical framework for making. In this poster, we present the design of a graduate course in teaching and learning in makerspaces for professional educators in K-16 settings. The course integrated embodied experiences with making, observations of students engaged in making, and literature on youth making in a variety of contexts. We analyze students' weekly reflections to understand teachers' sensemaking of making and its integration into their classroom instruction. We present findings about how teachers problematized white male normative making practices, recognized the relational nature of making, and considered issues of equity and access related to their own instructional practices.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Strand 3 Poster Session
4:45 PM-5:45 PM, Exhibit Hall

P15:
Changing Stigma on Wild Animals: A Qualitative Assessment of Urban Pupils' Pre- and Post-lesson Drawing
Chi-Chang Liu, National Taiwan University
Meng Wu, National Taiwan University

ABSTRACT
We assessed pre- and post-lesson drawings created by 27 urban pupils to see how they stigmatized wild animals and how the stigmatized perceptions could be eliminated by our lesson designed in light of

theories on reducing stigma. We articulated four kinds of stigma on wild animals which emerged from analysis of students' pre-lesson drawings. We compared pre- and post-lesson drawings to analyze changes between them and constructed four kinds of destigmatized perceptions on wild animals. The reflection on and elimination of stigma on wild animals may enhance our ability to improve the human-animal relationship which environmental education often seeks to build in a posthuman view.

P16:
Exploring the Applicability of Scientific Creativity Assessment Formula: Comparison of Assessments by Subjects
Minju Kim, Seoul National University of Education
Chae-Seong Lim, Seoul National University of Education

ABSTRACT
This study aims to compare self-, peer-, teacher-, and objective assessments of students' scientific creativity, using scientific creativity formula. A science-gifted class was given a peer-review activity, in which the students gave their presentations of something new and useful they devised using the Pascal's principle, at the Science-Gifted Education Center. The students' creative ideas were assessed by themselves, their peers, teachers, and the researchers using the formula. Ideas that satisfy both originality and usefulness standards can be considered scientifically creative. The main results of this study are as follows: First, the students applied lenient criteria to themselves in the assessment, and they also tended to be more lenient to their peers than teachers did. The average of teacher-assessment was lower than that of objective assessment, which showed that teachers applied quite strict standards for creativity. Second, the originality factor was found to be a more objective criterion than usefulness, which implies value judgement in evaluating usefulness. Third, the relevance of self- and peer-assessment implies it is necessary to consider students' review different from teachers'. These findings suggest that there are challenges for educators to construct consistent assessment methods for scientific creativity.

P17:
Metacognitive Scaffolds for Student Argumentation
Qingna Jin, University of Alberta

ABSTRACT
Understanding argumentation as both a cognitively demanding task (including both the cognitive level and the metacognitive level) and a form of social practice, this study was particularly focusing on the process of argumentation and exploring how students learn and participate in argumentation with the teacher's argument-focused metacognitive scaffolds. This 4-month-long case study was conducted in a Grade 5-6 science classroom. 18 students and 1 classroom science teacher participated in this study. During the research period, the science teacher provided some metacognitive scaffolds. Various methods such as classroom observation and interviews were employed to collect relevant data. Findings revealed that teacher's scaffolds helped students developed their metacognition in the context of argumentation (Mc-A), which impacted students' performances in various argumentative practices, including argument construction, argument evaluation and dialogical argumentation.

P18:
Pre-Service Early Childhood Teachers' Views and Suggestions about Successful Implementation of STEM-based Lessons
Ayse Ciftci, Mus Alparslan University
Mustafa S. Topcu, Yildiz Technical University

ABSTRACT
This study aims to investigate the difficulties encountered by pre-service early childhood teachers (PECTs) during the planning and implementation process of STEM-based lessons. The research was conducted with qualitative research method. Research was conducted with 39 sophomore PECTs. The open-ended questionnaire, focus group interview, and observation notebooks were used as data collection tools. The content analysis method was preferred for data analysis. At the end of the analysis, regarding the problems encountered in the planning process of STEM-based lessons, 5 themes were revealed: Identifying the problem, group work, children's development level, material selection and STEM integration. Regarding the implementation process, 6 themes were identified: Expressing the problem, group work, targeted instruction & implementations, children's development level, time management, and classroom management. It is important to detect the problems encountered by PECTs in the planning and implementation process of STEM-based lessons to overcome these problems.

P19:
Telling the Energy Story: Storytelling as A Resource in Science Learning
Panchompoo Wisittanawat, Vanderbilt University
Sara J. Lacy, TERC
Roger G. Tobin, Tufts University

ABSTRACT
Storytelling is an activity familiar to elementary school students, yet underutilized in science classrooms. This paper examines a curriculum that leverages storytelling for scientific sensemaking. The broader research project seeks to develop curricular support for the development of scientific ideas about energy in early elementary grades. The curriculum is organized around tracking energy changes and flow to "tell the energy story" of increasingly complex scenarios. We examine classroom videos of two 4th- and 5th-grade classrooms, attending to ideas about narrative and storytelling that students drew on in telling the energy story. We find that students drew on ideas about narrative structure (such as, a story has a beginning, a middle, and an end). We also find that, as in collaborative storytelling in everyday conversations, students posed challenges to each other as they construct the energy story. Resolving these challenges helped students clarify and elaborate on their energy story.

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

Strand 4 Poster Session
4:45 PM-5:45 PM, Exhibit Hall

P20:

Assessing the Effectiveness of a Novel Microscopy Technique in Middle School Science Classrooms

Sara P. Raven, Texas A&M University
Emel Cevik, Texas A&M University

ABSTRACT

Although research and new technologies have introduced different ways of observing microorganisms, including scanning and electron microscopy, these methods are expensive, and require unique pieces of equipment that are far beyond what is traditionally found in a middle school classroom. The TTD technique (Gregg, McGuire, Focht, & Model, 2010) is a new optical microscopy method that can be used with current basic light microscopes, and relies on the fairly simple mechanism of filtered light passing through a dyed medium to produce an image that reflects cell thickness. With this technique, living microorganisms look bright red against a dark background, and movement can be seen easily among dead microorganisms and debris that show up black. In this study, we evaluated how a 3-week inquiry-based unit focused on TTD microscopy affected middle school students' conceptual understandings of microscopy techniques and microorganisms using a pre-posttest design. Results showed a statistically significant difference between students' pre-test and posttest scores, and students reported having positive experiences using the TTD technique. As such, implications for teaching and research include providing new additions to traditional microscopy curricula as well as an educational evaluation of this method.

P21:

Empowerment of a Diaspora Through Science Education: Perspectives from Tibetan Teachers

Ngawang Y. Gonsar, Gustavus Adolphus College

ABSTRACT

The case study approach examined how cultural connections for Tibetan refugees are maintained and utilized in the classroom through the perspectives of two Tibetan science teachers. Deki and Tsultrim's perspectives are valuable because of their experience as students and now science teachers within the Tibetan refugee school system. I examined their motivations, how motivations manifest in the classroom and the complications in pursuing scientific knowledge for a diaspora refugee community. I identified 3 key motivations for teaching. These include service to the broader community, personal satisfaction in teaching, and the preservation of Tibetan cultural identity. I also identified tensions in teaching in Tibetan as compared to teaching in the common and dominant national language. Finally, I explored the difficulties of language comprehension and explored how refugee teachers negotiate to teach concepts within the tangible boundaries of living as a refugee. The broad relevance of this study is for educators to gain a deeper understanding of the influences surrounding science education for a diaspora community. Additionally, the elucidation of challenges in a larger framework provides direction to the exiled government towards policy changes to incentivize and provide an environment for the successful pursuit of science education for refugee students.

P22:

Exploring Chilean In-service Science Teachers' Understanding about Models and Modeling

Alexis Gonzalez, University of British Columbia
Carla Hernández, Universidad de Santiago de Chile
Damian Ruz

ABSTRACT
Model-based instruction has received increasing attention in the last decades as an effective teaching approach that engages students in the study of core practice in science. To do so, students need to develop epistemic practices regarding the creation, testing, enrichment, and modification of models. In Chile and many countries, the most recent educational science reforms aim at promoting a pedagogy that incorporates modeling practices through the engagement of students in gathering information, making predictions, working with evidence, manipulating mental or physical models, and communicating their learning (Khan, 2007). During the process of constructing models, teachers need to assist students in the generation, testing, evaluation, modification, and improvements of models to help them use models as resources to communicate, explain and predict phenomena (Nersessian, 2002; Windschitl, Thompson & Braaten, 2008). In the context of this study, we explored in-service teachers (ISTs) understanding about models and modeling to infer Chilean ISTs' pedagogy in model-based teaching. The purpose of this study was twofold. First, it was aimed to identify ISTs understanding about models (nature and purpose of models) and modeling. Secondly, to explore ISTs' teaching strategies to implement MBT in order to teach and assess students during the construction of models.

P23:
Have the NGSS Changed Science Instruction to Include Engineering? A Review of the Literature
Stephanie D Teeter, NC State University

ABSTRACT
One goal of the Next Generation Science Standards (NGSS) is to tie engineering design, engineering-thinking, and technology into classroom science instruction. This review aims to see if these new standards have changed how engineering is included in middle school and high school classrooms. Specifically, it examines what science subjects have tried integration, the degree of integration, the types of data collected, and whether or not the authors deemed the integration to be successful. Ultimately, this review revealed no clear differences in these four criteria before and after the creation of the standards. However, common themes emerged regarding the importance of collaboration between educators, engineers, and university members when creating curriculum and also the importance of providing professional development to teachers attempting to integrate engineering. One additional finding, though beyond the scope of the research questions, was that engineering design instructional approaches had significant impacts on special education and racial minority students. This review marks a starting point for comparing changes that result from the new NGSS standards and may provide a useful literature base for research addressing the inclusion of engineering in middle and high school classrooms.

P24:
Introducing application based Nanotechnology modules to high school students: Results from an exploratory pilot.
Tejaswini S. Dalvi, Universty of Massachusetts
Martyna Laszcz, Graduate Student

ABSTRACT
As the nanoscience and nanotechnology (NST) field becomes more desirable in terms of careers and scientific study, many students are still not being exposed to the fundamental concepts of NST such as size and scale or innovations and applications of nanotechnology. Teaching NST concepts can not only spark students' interest in science, math, engineering, and technology subjects but can eventually lead to STEM career paths as well. Our study aims to create a nanoscience lab module about the workings of

an atomic force microscope (AFM), and make it accessible to students at the 8-12 grade level. In this study, we introduce eighth grade students to both a Lego model of an AFM as well as a real one by first using the Lego model to explore the tool and then using the real AFM to study physical properties of materials. We report on results from a wide set of data including pre- and post- attitude surveys, individual reflections and group work among students. We find that the trends from these results tell us that students are ready to engage with NST topics and concepts, and willing to explore the underlying science that comes with them.

P56:

Teachers' Intersection of Computational Thinking and Data Practices to Support Student Data Analysis during Science Investigations

Erin E. Peters-Burton, George Mason University
Laura Laclede, George Mason University
Stephanie Stehle, George Mason University
Peter J. Rich, Brigham Young University
Anastasia Kitsantas, George Mason University
Timothy Cleary, Rutgers University
Kimberly Mcleod, George Mason University

ABSTRACT
Computational thinking (CT) is an approach to solving problems that requires students to think recursively, seek patterns, and use abstraction and decomposition in tackling large complex problems. CT can be a useful supplement to data analysis during scientific investigations. The purpose of this study was to examine how high school science teachers use CT practices to support student engagement in data analysis following a professional development program and to determine viable intersections between data practices and CT that have utility for enhancing student learning. Multiple case study design was used to examine teacher background on CT knowledge, beliefs, and experiences, the design of CT supports in lesson plans, and the outcomes of CT supports implementation in the lessons. Across the teachers, the CT practice of decomposition had the most improvement in knowledge and application. In teachers' planned lessons, decomposition was the most frequently used CT practice and it was typically paired with creating data. Similarly, pattern recognition and abstraction were categories where teachers learned more formal knowledge in the PD. Pattern recognition was most paired with collecting data, and abstraction was most paired with analyzing data. Implications for designing PD and lessons will be discussed.

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

Strand 5 Poster Session

4:45 PM-5:45 PM, Exhibit Hall

P26:

A Model to Assist in Combatting STEM Graduate Student Imposter Syndrome

Julianne A. Wenner, Boise State University
Paul Simmonds, Boise State University
Megan Frary, Boise State University
Donna Llewellyn, Boise State University

ABSTRACT
Graduate students in STEM often battle Imposter Syndrome (IS) or a sense of 'intellectual phoniness' during their graduate programs. IS is often more intense for students who are from underrepresented minority (URM) groups who already face systemic inequities in academia. Professional identity development is known to combat IS, dispel feelings of disconnection from professional colleagues, and promote persistence in schooling and the achievement of professional goals. Professional identity is particularly important for students from URM groups, as connections with a profession or discipline can serve as a buffer from negative stereotypes. Consequently, we crafted a model designed to support the cultivation of GS professional identity and explored how the model impacts GSs' feelings of IS and what components of the model appear to be key in combatting IS. Using multiple data sources over three iterations of the model, our data indicate that the model was successful in helping GSs feel a commitment and sense of belonging to their discipline, and that the combination of two major components of the model was vital to combatting IS and cultivating a strong professional identity.

P27:
Characteristics of Effective Professional Development for Undergraduate Science Instructors: A Critical Review of the Literature
Katherine McCance, North Carolina State University
Soonhye Park, North Carolina State University

ABSTRACT
Undergraduate STEM instruction remains largely lecture-based, despite overwhelming evidence that student-centered teaching methods improve student outcomes. Several barriers prevent college instructors from adopting student-centered teaching practices, including having little to no formal pedagogical training. Although effective professional development (PD) models for K-12 teachers exist, a PD framework for undergraduate instructors has not been identified. This critical literature review analyzes features and findings of 37 empirical studies on PD programs for undergraduate science instructors (faculty, postdocs, graduate teaching assistants) published from 2003-2018. PD programs included in this study were analyzed using the five features of effective PD (Garet et al., 2001). Long-term involvement, focus on pedagogy and application, active learning, and collaboration were features that supported effective PD for undergraduate instructors. The reviewed literature reports instructor outcomes, and student outcomes to a lesser extent, to assess PD programs. The literature has a high degree of alignment with the PD model for K-12 with a few discrepancies that should be considered when designing PD for undergraduate instructors. As there is no framework for key features of effective PD for undergraduate instructors, this study lays foundations for developing a framework and suggests future PD that includes mentoring and student outcomes measurements.

P28:
Chemistry students' understanding of dissolving and associated phenomena: The case of sodium chloride
James M. Nyachwaya, North Dakota State University
Krystal Grieger, North Dakota State University

ABSTRACT
This study sought to uncover college general chemistry students' understanding of the process of dissolving, and properties of the resulting solution. Students (working in groups) were asked to describe the process of dissolving sodium chloride in water, provide a particulate drawing of interactions in the solution, explain whether the amount of water changes after dissolving, and how the entropy of the solution would compare to that of water (solvent). Preliminary results indicate that only six of the forty-

six groups appropriately described dissolving. None of the forty-six groups provided an appropriate drawing of interactions in solution. While forty groups correctly predicted that the amount of water would remain the same after dissolving, only thirteen groups provided the correct reason for their prediction. Forty-three groups were correct in noting that entropy of the solution would be higher than that of the pure solvent. However, only four groups gave the correct reason for entropy of the solution being higher. While students in most groups invoked relevant academic language, the use of the language in many groups points to a lack of understanding of fundamental chemistry concepts.

P29:

College students' perceptions of STEM and choices of switching out of initial STEM majors

Youngjin Song, California State University, Long Beach
Lisa M. Martin-Hansen, California State University, Long Beach

ABSTRACT

The study describes how college students who switched out of their initial STEM (Science, Technology, Engineering, and Mathematics) majors perceived the interdependence of STEM disciplines and how their perceptions related to their choice of switching majors. The primary data were collected from the interviews of 23 participants at the 4-year public university. According to the final major choice, the participants were categorized into three groups: STEM to STEM, STEM to STEM-adjacent, and STEM to non-STEM switchers. The participants perceived the interdependence of STEM disciplines at different levels. One group demonstrated their understanding of how STEM disciplines were interrelated (sophisticated). The second group commented on their idea of STEM as being “hard” or something that helped you make a lot of money (superficial). All of the participants’ understandings of STEM were related to their choices of switching majors to some extent. All but one STEM to STEM switcher demonstrated more sophisticated understandings of STEM. Learning more about the interdependence of STEM disciplines pushed some students out of the STEM major. The participants who demonstrated superficial understanding did not show clear patterns in regard to where they switched. The study has implications to the phenomenon of college STEM switching.

P30:

Cultivating Water Literacy in Undergraduate STEM Education: Students' Socio-scientific Reasoning about Socio-hydrologic Issues

David C. Owens, Georgia Southern University
Destini N. Petitt, University of North Carolina-Charlotte
Diane Lally, University of Nebraska-Lincoln
Cory T. Forbes, University Of Nebraska–Lincoln

ABSTRACT

In an increasingly resource-limited world, it is essential to support students’ development of sophisticated reasoning skills when considering complex environmental systems. To address this need, we developed and implemented an introductory undergraduate course focused on water systems and their human dimensions, or ‘socio-hydrologic’ systems. The study focused on participants’ (N=91) development of hydrological content knowledge and socio-scientific reasoning (SSR) through use of a Hydrologic Concept Inventory and a 5-item Quantitative Analysis of Socio-Scientific Reasoning (QuASSR) task grounded in a real-world, regionally-relevant socio-hydrologic issue (SHI). Participants’ hydrological content knowledge significantly increased during the course, and several students exhibited sophisticated reasoning regarding the different dimensions of SSR, though the breadth and depth of the SSR they exhibited varied both within and between the dimensions of SSR, and a number of students’

SSR was highly limited. A significant relationship between students' understanding of hydrological concepts and their SSR was not observed. These findings provide evidence that a course designed specifically to develop water literacy can significantly increase their understanding of water-related concepts. Additionally, the insights afforded here have implications for the facilitation of instruction that directly supports student development of SSR, and for operationalizing, measuring, and describing undergraduate students' SSR in undergraduate classrooms.

P31:
Do International Teaching Assistants Negatively Impact Student Outcomes in Biology?: A Comparative Study
Zhigang Jia, Middle Tennessee State University
Lisa L Walsh, University of Michigan

ABSTRACT
In most American universities, undergraduate students are largely introduced to college-level science by graduate teaching assistants (GTAs). Undergraduate student outcomes in early courses affects their decision to pursue a STEM degree, situating GTAs in a potentially impactful role in STEM retention. First-time GTAs express concerns including feeling unprepared for the job and receiving limited support, especially for international teaching assistants (ITAs). To better understand how ITAs and domestic GTAs impact undergraduate students in biology, we surveyed 1065 students and their 31 GTAs across three semesters in a gateway biology course. Undergraduate surveys evaluated interest in a STEM major and course grades because higher grades in gateway courses increase the likelihood of majoring in STEM. We found that overall grade and change in STEM interest across the semester did not differ between students taught by ITAs and domestic GTAs. Students taught by ITAs received significantly higher paper grades than those taught by domestic GTAs. Our results indicate that paper grading techniques are an important topic to cover for ITAs when designing professional development. ITAs showed no negative impacts on overall grades or student interest in pursuing STEM, comparing to domestic GTAs.

P32:
Symbolic-Mathematical Model Comprehension in Physical Chemistry
Ines Komor, University of Duisburg-Essen
Helena Van Vorst, University of Cologne
Elke Sumfleth, University of Duisburg-Essen
Julian Roelle, Ruhr-Universität Bochum
Eckart Hasselbrink, University of Duisburg-Essen

ABSTRACT
Model-based thinking is essential for learning and teaching science. Especially in Physical Chemistry, symbolic-mathematical models are often used. As there had not been any earlier research analyzing why undergraduates often fail solving mathematic-based chemical problems, a preliminary interview study focusing on the analysis of undergraduates' main problems in deducing, using and understanding symbolic-mathematical models in Physical Chemistry was conducted. A qualitative content analysis showed that undergraduates have most difficulties in mathematising the chemical model and working mathematically. Based on these findings, a diagnostic instrument measuring symbolic-mathematical model comprehension focusing the steps which have been proven to be problematic, has been developed. This study focuses on the evaluation of a diagnostic instrument. To evaluate the diagnostic instrument an example-based training program fostering symbolic-mathematical model comprehension has been used. The training likewise the test instrument focus on meta knowledge concerning the

process of mathematical modelling to provide students a general guideline for solving tasks in Physical Chemistry. According to that, there are three different categories of items (mathematisation/working mathematically/meta knowledge). A Rasch analysis shows that the diagnostic instrument is appropriate to measure students' symbolic-mathematical model comprehension. Furthermore, a dimensionality analysis shows that there are only two dimensions: meta knowledge and mathematics.

P33:

The Implications for STEM Retention and Career Aspirations Through a First-Year Biology Seminar

Krista Lucas, University of California at Santa Barbara
Danielle Boyd Harlow, University Of California At Santa Barbara

ABSTRACT

There continues to be more STEM jobs than qualified graduates to fill these positions. We know that of students who enter college intending to pursue STEM, nearly half do not finish their STEM degree. This makes recruiting students into STEM majors insufficient. Here, we focus on retainingstudents who enter college with a declared biology major. This qualitative study examines this retention issue through the lens of identity theory, situated learning, and constructivism, in the context of a research-focused biology first-year seminar at a small, private university. It was found that the six participants felt more like scientists at the conclusion of the semester-long seminar, and all were planning to remain in the biology major and in STEM career pathways.

Strand 6: Science Learning in Informal Contexts

Strand 6 Poster Session

4:45 PM-5:45 PM, Exhibit Hall

P34:

Family Interpretations of Conservation Messaging at an Aquarium exhibit

Victoria J. Reyes, Texas State University
Jennifer L. Idema, Texas State University
Kristy L. Daniel, Texas State University

ABSTRACT

Aquaria provide opportunities for families to interact with nature through a controlled environment coupled with relevant messaging. Conservation, a socioscientific issue, can be a complex and controversial topic. Aquarium staff are often tasked with making decisions about how to present such messages through exhibits. The purpose of this qualitative study was to understand family interpretations of a socioscientific message being communicated through an aquarium exhibit. We used data from exhibit observations, interviews with staff and family visitors, and video observations of visitor interactions to identify how an aquarium chose to present a water conservation message and how adult and children visitors interpreted the message after exhibit interactions. We used inductive and deductive approaches to analyze data identifying exhibit design elements, intended messaging, interpreted messaging, and biometric focal interactions by visitors. We found evidence that adults and children have different experiences and understandings even when interacting with an exhibit concurrently, adults spent more time on signage and children spent more time on live organisms. We also found most visitors ended their experience with a partial interpretation of the intended message. Thoughtful design is needed to support varying ways visitors interact with exhibits in order to improve messaging interpretation outcomes.

P35:

Investigating Influences, Affordances & Challenges of a Summer Teen Program

Lara Smetana, Loyola University Chicago
David Bild, Chicago Academy of Sciences Peggy Notebaert Nature Museum

ABSTRACT

Out of school programs have moved away from focusing solely academic and workforce outcomes to also prioritize social, emotional and intellectual development (Nagoaka et al., 2015). This jointly negotiated research explores the design and implementation of summer teen program aimed to foster a positive relationship between teenage youth and local urban nature, while also promoting positive youth development. This poster analyzes key elements of the program design, reports on affordances and challenges, and reflects on lessons learned for this particular program as well as for other out-of-school science program practitioners and researchers.

P36:

Linking family engagement activities to common learning outcomes at touch tank exhibits

James F. Kisiel, California State University, Long Beach
Shawn M. Rowe, Oregon State University
Tamara Galvan, Facilities Director, Feiro Marine Life Center

ABSTRACT

Marine touch tanks, featuring a variety of living animals (sharks, rays, sea stars, sea urchins) continue to be a popular exhibit at zoos, aquariums and even science centers around the world; the study of this unique interactive science exhibit continues to grow as well. Although research has shown a variety of common activity routines at these common exhibits (Authors, 2012), few studies have linked activities to specific learning outcomes. This mixed-methods study, using video-based observation and post-exhibit interviews, identifies common outcomes resulting from family engagement (e.g. identifying basic physical characteristics, recognizing common behaviors, understanding physiological functions) with these exhibits in two Southern California aquariums. By linking common outcomes with activity frequencies for each of the participating family groups (N=23), we see several activity-outcomes emerge, suggesting that a prevalence of particular activities might be attributed to certain learning outcomes. Interpretation of these activity patterns is discussed with implications for practice.

P37:

Pedagogical structures and student agency: How do teachers of after-school Science clubs strike a balance?

David J. Schouweiler, University of North Carolina at Greensboro
Sara Heredia, The University of North Carolina Greensboro
Edna Tan, University Of North Carolina At Greensboro

ABSTRACT

In constructing Maker-oriented activities for youth, facilitators must make decisions about the degree of autonomy to provide students. In some spaces, facilitators implement fewer structures, which can afford more modes of participation for Makers. However, complete Maker autonomy can present other challenges, such as logistical issues and a failure to challenge structures that deepen inequitable access to Making. In this paper, we present a comparative case study of two middle school after school STEM clubs that culminated in Maker projects designed to address local stormwater issues. In one club,

facilitators implemented fewer structural constraints, enabling broader access to varying modes of participation for the youth. At the other club, facilitators used more structures to focus the activities of Making, resulting in a more finished product, but at the expense of youth agency. We explore the influences of the structural features of each club on youths' capacities to learn through Making, iterate on their designs, and engage in equitable and consequential Making. We further explore ways in which structures to which the facilitators were subject influenced the facilitators' design decisions for each club. Implications for supporting Making facilitators and designing Makerspaces for balancing structure and agency are explored.

P38:

Seeing Social Learning: Using Social Network Analysis to Operationalize Communities of Practice

K.C. Busch, North Carolina State University
Kathryn Green, University of Georgia
Lynn Chesnut, North Carolina State University
Kathryn T. Stevenson, North Carolina State University

ABSTRACT

Communities of Practice (CoP) can be found in classrooms, in clubs, in workshops, and in professional organizations. Many educational interventions aspire to create communities of practice to improve individual learning outcomes and group-level functioning (Wenger, McDermott, & Snyder, 2002). However, operationalizing a CoP can be challenging (Addicott, McGivern & Ferlie, 2006), making documenting such changes difficult. The purpose of this proposed poster is to show, through an exemplar case study, how social network analysis can be used to operationalize social learning in a Community of Practice.

Strand 7: Pre-service Science Teacher Education

Strand 7 Poster Session

4:45 PM-5:45 PM, Exhibit Hall

P39:

A Bridge between Theory and Practice: Field-Based Experiences in Science Teacher Education Programs

Hatice Ozen-Tasdemir, University of Georgia
Julie A. Luft, University of Georgia

ABSTRACT

Field-based experiences are one of the essential parts of teacher preparation programs. These practices provide an authentic learning environment for teacher candidates. This study tackles the important issue of field experiences by examining the structure of field-based experiences in undergraduate science teacher education programs at the secondary level in one region. The research focuses on how field experiences integrated into science teacher preparation programs in one area of one state, and how field experiences of science teacher preparation programs aligned with the literature. This study indicated that all selected universities offered field experiences, but the nature of these experiences was different. Only one university provided a great variety of field experiences in terms of teaching opportunity, and only one university provided a massive range of learning opportunities to pre-service science teachers. In terms of assessment of field experiences, all universities evaluated the performance of teacher candidates during their field experiences and student teaching or internship stage with

evidence-based assessments. Although many science teacher preparation programs include field experiences, the quality and amount of these experiences is still an issue.

P40:

Analysis of Secondary Pre-service Science Teachers' Questioning during Microteaching

Elsun Seung, Indiana State University
Eunmi Lee, DePaul University
Aeran Choi, Ewha Womans University
Jinhong Jung, North Carolina Central University

ABSTRACT

With explicit emphasis on scientific practices in the science classroom, examination is needed to determine if pre-service teacher education programs prepare their candidates with appropriate support to engage students in their learning processes to conduct investigations, explain natural phenomena, and engage in discourse. Science teacher questions during instruction can support student cognitive processes while they engage in scientific practices and construct their scientific knowledge. This study examines (1) the relationship between the cognitive levels and degree of divergence of the questions that pre-service science teachers use during their microteaching, and (2) the relationship between the purposes of questions and the cognitive levels of the questions. The results of this study reveal that pre-service science teachers use both closed-ended and open-ended questions, but few use questions that prompt students' high-order cognitive skills.This study also indicates that different question types by purpose are used to support different cognitive levels. Results suggest that pre-service teacher education programs should provide opportunities for pre-service teachers to reflect on and improve their questioning skills before student teaching in order to achieve the goals of the new standards-based science education for enriching student learning by engaging them in scientific practices.

P41:

Elementary Pre-service Teachers' Perceptions of Assessment Tasks to Measure Content Knowledge for Teaching about Matter

Dante Cisterna, Educational Testing Service
Jamie N. Mikeska, Educational Testing Service (ETS)
Allison Bookbinder, Teachers College, Columbia University
David L. Myers, University of Georgia
Heena R. Lakhani, University of Washington
Luronne Vaval, Teachers College, Columbia University

ABSTRACT

This study explores how 79 elementary pre-service teachers evaluate the importance and pertinence of assessment tasks, designed to elicit information about content knowledge for teaching (CKT) about matter—a foundational topic for physical science. Drawing on a cognitive perspective and using think-aloud procedures, we had the participants answer different assessment items that described teaching scenarios related to elementary science instruction for topics such as properties of matter, changes in matter, the model of matter, and conservation of matter. We aimed to explore (1) how familiar pre-service teachers felt these task scenarios were in regards to their (pre-service) teaching experience and (2) how important they considered these task scenarios for the work of elementary teachers. Findings suggest that pre-service teachers tend to recognize the centrality of these tasks for the work typically done in elementary classrooms, even if they do not report having firsthand experience with the scenarios. Participants, however, tended to provide a general rationale about why these tasks were

important for the work of teaching. Only a limited number of responses made explicit connections between a task scenario and the specific practice related to teachers' work. This study poses implications for CKT assessment design and elementary education programs.

P42:

Examining Elementary Preservice Teachers' Understanding of Natural Selection Through Technology

Nicole Juliana Thomas, University of Nevada, Las Vegas
Tina Vo, University of Nevada- Las Vegas

ABSTRACT

Natural selection is a staple concept outlined in the NGSS however, some students may lack a baseline understanding of it. The concept of natural selection is first introduced to elementary students as they begin to explore the concepts of inheritance, variation, and diversity in traits. These standards begin to form the base of a structure that ultimately lends itself to understanding pivotal biological concepts and theories. This pilot study aimed to measure the practicality of using a web-based simulation in order to instruct a group of preservice science educators regarding the topic of natural selection, answering the research question: what ideas do elementary preservice teachers explicitly consider when using simulation technology about natural selection? By administering this simulation to preservice teachers, we were able to identify potential gaps in their knowledge of natural selection. Students were asked to identify which traits would confer higher fitness. Student reflections afforded students the opportunity to document their experience with using simulations to address biological concepts. This aided us in identifying and addressing gaps in natural selection knowledge within this specific classroom setting, with the overall response to the use of technology inside of the classroom as being beneficial as opposed to detrimental.

P43:

Lesson Study Preparing Preservice Elementary Teachers for Science PBL and Working with Language Minority Children

Peter Rillero, Arizona State University
Ying-Chih Chen, Arizona State University

ABSTRACT

Lesson Study (LS) has been used successfully in Japan and then other nations for promoting climates that foster inservice teacher development. This study used the LS approach as an overarching method to develop preservice teacher understanding and skills of Problem-Based Enhanced Language Learning (PBELL). This model combines Problem-Based Learning (PBL), language-based theories of learning, and methods of working with students developing abilities in the language of instruction. The LS framework builds upon previous elements used for preservice teachers including modeling a PBELL experience designed for second graders; use of an online, interactive PBL module; and PowerPoint instruction about the approach. This presentation describes the PBELL approach, the sequence of experiences for preservice teachers, and—using analyses of a retrospective survey and interviews—perspectives of the preservice teachers on their knowledge growth and skill development, and the value of the components of the sequence. The preservice teachers indicated they grew in their understanding of PBELL and abilities to implement it. The most valuable component was the model PBELL experience and the group implementation of the experiences using the LS framework.

P44:

Learning to Teach for Promoting Cognitive Demand on Student Thinking in Science Classrooms

Miray Tekkumru Kisa, Florida State University
Ryan Coker, Florida State University
Sebnem Atabas, Florida State University

ABSTRACT

There is growing attention to improving pre-service teachers' (PST) capacity in enacting ambitious teaching practices that entail uncovering students' ideas and elevating them to the public space to advance their understanding and engagement in rigorous intellectual work. As part of a larger effort to support PSTs' learning to develop ambitious teaching through a video-based methods course, in the current study we explored how PSTs come to develop discourse practices for promoting cognitive demand on student thinking through appropriating the pedagogical tools about the design and enactment of cognitively demanding and responsive science instruction. In our analysis, we used five PSTs' lesson planning, implementation, and reflection on a two-day lesson in the methods course and the interviews during their internship. Our analysis revealed a variation in PST's orientations to student thinking as reflected in their use of the five practices while planning for a science lesson and in their maintenance of cognitive demand while teaching. These patterns were consistent with their appropriation of the pedagogical tools for promoting cognitive demand on student thinking. The study provides implications for effective designs for supporting novice teachers' learning.

P45:

Impacting Preservice Elementary Teachers through Physical Science Educative Curriculum Materials

Brooke A. Whitworth, University of Mississippi
Lauren Simpson, University of Mississippi
Whitney Jackson, University of Mississippi
Julie James, University of Mississippi
Alice Steimle, University of Mississippi

ABSTRACT

This mixed methods exploratory study examined how the development of physical science educative curriculum materials designed specifically for preservice elementary teachers impacted attitudes and interests in science. One cohort of students (n = 80) were placed in treatment (n = 40) and control (n = 40) sections of a physical science course at a higher education institution in the southern United States. Faculty members in the treatment course utilized specially designed educative curriculum materials for the course. Data sources included the PETAS-S, interviews with students, observations, and artifacts. Data were analyzed using a-priori codes and following Teddlie and Tashakkori's (2009) protocol for integration. Findings begin to examine the design principles of educative curriculum materials for use in the higher education classroom to improve preservice elementary teachers' attitudes and interests toward science. We begin to suggest design principles for future ECM development.

Strand 8: In-service Science Teacher Education

Strand 8 Poster Session

4:45 PM-5:45 PM, Exhibit Hall

P46:

Challenges in professional development programs aiming at teaching inquiry thinking strategies

Elina Lustov,
Anat Zohar, The Hebrew University of Jerusalem

ABSTRACT

This study examines the challenges that characterize a PD process focusing on the development of science teachers' inquiry-related thinking strategies and the pedagogical knowledge required for teaching them. The study is conducted as part of an online PD course focused on inquiry-based teaching and learning. 54 physics teachers who studied in the course participated in this study. The data was collected from authentic assignments written by teachers during the course while practicing the pragmatic research method. The teachers' experience in the classroom is analyzed using the inquiry skills rubrics, which include a list of inquiry strategies and their components. The study exposes some of the challenges involved in a PD development program focused on inquiry-based teaching and learning. Such as: The initial knowledge of many teachers in that area is weak. Most teachers apply the thinking strategy in a simple form, ignoring the more sophisticated aspects of its application that require more complex thinking. Teachers' understanding of the pedagogical knowledge involved in teaching a thinking strategy is limited. These findings make an important contribution to the teaching of science in general and to members of the NARST community in particular.

P47:

Engineering Teacher Pedagogy: Using INSPIRES to Support Integration of Engineering Design in HS Biology Classroom

Jonathan Singer, University of Maryland, Baltimore County
Jacqueline Krikorian, University of Maryland Baltimore County
Tory H. Williams, University of Maryland Baltimore County
Christopher Rakes, University of Maryland Baltimore County
Julia Ross, Virginia Tech

ABSTRACT

The present study continues our examination of changes in high school science education pedagogy during a three-year professional development (PD) program using the INSPIRES educative curriculum. The Next Generation Science Standards (NGSS) call for the integration of science and engineering through inquiry-based pedagogy that shifts the burden of thinking from the teacher to the student. This call is especially challenging for teachers untrained in inquiry teaching and engineering or science concepts. The "NSF grant-funded" educative curriculum-materials and PD provided a mechanism for teachers to transform their teaching to meet the NGSS challenges. This study followed a longitudinal triangulation mixed methods design. Selected lessons were recorded, scored on the Innovation Configuration (ICmap) rubric, and examined for qualitative trends. Two teachers were further examined as case studies. Results indicated that teachers had begun to transform their teaching, and particular lessons within the "NSF grant-funded" curriculum best facilitated the reform. These findings provide insights for structuring PD to make more targeted use of an educative curriculum aligned with intended PD goals. PD that supports teachers in implementing a strongly-written engineering educative curriculum can allow the transfer of design-based pedagogy into teacher-developed curricula.

P48:

Teachers' Beliefs about the Importance and Value of the NGSS Science Practices

Soonhye Park, North Carolina State University
Gary W. Wright, North Carolina State University
Vance J. Kite, North Carolina State University

ABSTRACT

The purpose of this study was to identify the NGSS science practices secondary science teachers identified as most important, and to determine what type of value they ascribed to those practices. An Electronic survey was used to collect quantitative and qualitative data from 128 science teachers. Quantitative data were analyzed using descriptive statistics and average ranking scores, and qualitative data were analyzed through qualitative content analysis. The expectancy-value theory (Wigfield & Eccles, 2000) served as both a theoretical and analytic framework for the study. Data analysis indicated that teachers ranked asking questions as the most important scientific practice, and most frequently attached attainment value to the scientific practices that they chose to be most important for student science learning. Using mathematics and computational thinking was the lowest ranked science practice and teachers did not see this practice as being applicable beyond the classroom nor as a means of motivating students or building competence. This study highlights the beliefs that secondary science teachers hold towards the importance and value of the science practices recommended by NGSS and lays the groundwork for research examining the alignment of teacher perceptions and instructional practice, especially in the context of NGSS science practices.

P49:

Collaborative Pedagogical Reasoning of Beginning Science Teachers in a Professional Learning Community

Aeran Choi, Ewha Womans University
Soonhye Park, North Carolina State University
Elsun Seung, Indiana State University

ABSTRACT

This study aimed to investigate characteristics and features of pedagogical reasoning in a professional learning community. Three novice middle school science teachers who a common goal of designing science lesson plan created a professional learning community and had weekly meetings. They discussed to develop science lesson plans and further reflected their science teachings. Main data sources included transcribed audio-recordings of 34 weekly meetings of three science teachers in a professional learning community. Average of each meeting was three hours. Data analysis revealed first, that pedagogical reasoning in a professional learning community comprises not only preparation, representations, instructional selections, and adaptation but also reflection and new comprehension in Transformation stage. Reflection in Transformation stage had two features: (a) reflection on lesson plan drafts that leads teachers to be engaged with each subcomponent (preparation, representations, instructional selections, and adaptation) of Transformation stage; and (b) reflection on instruction and evaluation experiences. Second, pedagogical reasoning in a professional learning community was nonlinear and dynamic in Transformation stage. Through interactions among teachers in a professional learning community, subcomponents in Transformation stage were continuously activated and influenced by others.

P50:

Exploring Relationships amongst Node-level Variables and Teachers' Social Networks

Sara L. Salisbury, Middle Tennessee State University
Brock Couch, Middle Tennessee State University
Samuel J Polizzi, Middle Tennessee State University
Yicong Zhu, Stony Brook
Gregory Rushton, Middle Tennessee State University

ABSTRACT

Research continues to suggest that teachers face barriers when attempting to implement reform-minded science teaching practices. Engaging teachers in opportunities allowing them to network and share their ideas and experiences helps these teachers develop their professional networks and access social capital, which can help them overcome hurdles to implementation. However, there are several issues at the school and district level that may prohibit teachers from accessing these opportunities. Using egocentric and visual network scales approaches to social network analysis, we sought to better understand the antecedents to Noyce scholar teachers' social capital development by exploring connections between node-level variables (e.g., socioeconomic status and teaching location) and network variables (e.g., network size and density). Findings from this study suggest that previously-identified barriers to the development of network variables were not significant across our population. This suggests that teachers in this study may be utilizing additional networking tools (e.g., social network sites, listservs) to access additional teaching resources, or may have more meaningful and fruitful connections within their existing networks.

P51:

GST-Integrated PD to Promote Interdisciplinary Approaches to STEM Education

Wm. Matthew Reynolds, North Carolina State University
Soonhye Park, North Carolina State University
Eric Money, North Carolina State University
Kyle Bunds, North Carolina State University

ABSTRACT

Spatial thinking has been shown to be necessary for success in science education and is required by many 21st-century STEM careers. Geospatial technologies (GST) have been widely advocated in K-12 education as a vehicle for improving spatial thinking skills and problem-solving skills; however, without proper training teachers' often lack the knowledge, skills, and confidence needed to integrate GST in their classroom (Moore et al., 2016). This study aimed to design and pilot a systematic, intensive 4-day professional development (PD) for teachers from high-need middle and high schools to develop the competency required to integrate GST into their classrooms. In particular, through the PD, we intended to improve: (a) teachers' knowledge of GST, (b) geospatial thinking skills, (c) self-efficacy in integrating GST into their curriculum, and (d) ability to effectively plan and implement GST-integrated lessons. At the conclusion of the GST-focused PD, teachers reported higher efficacy with the use of assorted GSTs to teach STEM curriculum and described being able to decide how best to apply various options to meet their pedagogical goals. This GST-focused PD demonstrates the tremendous potential of GST to engage students in learning core science concepts and other STEM-related issues.

Strand 10: Curriculum, Evaluation, and Assessment
Strand 10 Poster Session
4:45 PM-5:45 PM, Exhibit Hall

P52:
Assesment of K-12 Students' Science and Literacy Knowledge
Claire Cesljarev, Indiana University
Valarie L. Akerson, Indiana University

ABSTRACT
Incorporating literacy instruction in science is a beneficial practice using interdisciplinary strategies to holistically address connections between subjects and provide more robust understandings of content. This interdisciplinary curriculum requires the teachers to apply a common methodology and language to instruction. While ideas for lessons and strategies for incorporation of literacy in science are plentiful, the field falls short in providing guidance on assessment of proficiencies in the two subject areas. Therefore, it is critical that teachers who may not be literacy specialists receive support in not only teaching science through literacy, and literacy through science, but also in assessing student learning outcome of science and literacy content to ensure appropriate learning of all teaching objectives is obtained. The purpose of this project is to explore challenges for interdisciplinary science and literacy assessment to determine how teachers can not only design the assessment tools but use them effectively to identify student learning in literacy and science instruction. This presentation will provide our analysis of interdisciplinary science and literacy assessment strategies across grade levels, and recommendations of assessment behaviors that will be useful for teachers involved in incorporating literacy curricula into science instruction.

P53:
Designing Educative Curriculum Materials for Teacher Educators: Supporting Elementary Teachers' Content Knowledge for Teaching about Matter
Deborah L. Hanuscin, Western Washington University
Emily J. Borda, Western Washington University
Josie Melton, Western Washington University
Jamie N. Mikeska, Educational Testing Service (ETS)

ABSTRACT
Building on the work of Ball and Cohen and that of Davis and Krajcik, as well as more recent research related to K12 teacher learning from and about curriculum materials, we seek to answer the question, How can educative curriculum materials be developed to support teacher educators in acquiring the knowledge needed for teaching science teachers? We present a set of theoretically and empirically based design principles and conceptual examples of ways in which educative curriculum materials might be used to support teacher educators in developing the knowledge needed for teaching elementary pre-service teachers. Specifically, we focus on helping teacher educators develop prospective teachers' content knowledge for teaching about the structure and properties of matter. We follow these examples with consideration of unanswered questions related to the use of educative curriculum materials by teacher educators.

P54:

Development and Validation of a Rating Scale to Assess Modeling Competence

Anna Beniermann, Humboldt University of Berlin; Institute for Biology
Dirk Krueger, Freie Universitaet Berlin
Annette Upmeier Zu Belzen, Humboldt-Universität Zu Berlin

ABSTRACT

Models are essentially embedded in science education curricula around the world. They are either used as media to communicate about scientific originals, or as method when used as a research tool to generate and test hypotheses. These different perspectives on models are illustrated in the framework for modeling competence (FMC) that represents a two-dimensional structure of aspects and levels of modeling competence. Different empirical findings using decontextualized open-ended tests or closed formats that are embedded in a biological context fundamentally supported the theoretical structure of the FMC. We aimed to develop an economic rating scale to assess modeling competence detached from any special scientific contexts that can function as a diagnostic tool in different contexts and disciplines. The modeling competence test was developed in an iterative process based on a pool of utterances from decontextualized open-ended surveys that were coded concerning the level of modeling competence by independent raters. In this presentation the results of a pilot study with pre-service biology teachers (N = 48) are introduced. The findings indicate that the modeling competence test can help diagnose and subsequently foster a scientific application of models in science education.

Strand 11: Cultural, Social, and Gender Issues

Strand 11 Poster Session

4:45 PM-5:45 PM, Exhibit Hall

P55:

Indonesian biology teachers' perceptions of the theory of evolution: A multiple-case study

Arif Rachmatullah, North Carolina State University
Minsu Ha, Kangwon National University
Jun-Ki Lee, Division of Science Education, Chonbuk National University
Sein Shin, Chungbuk National University

ABSTRACT

Teachers have their own and distinct perceptions of theory of evolution that are affected by their personal background, such as religious and moral values as well as their educational background. This study aims at exploring Indonesian Muslim biology teachers', a not-well explored population, perceptions of the theory of evolution, and teaching it in Indonesia. A multiple-case study approach was used in this study. Interviews and documents analyses were used to gather the data. Three Muslim teachers participated in this study, and each teacher was considered as one case given their distinct teaching background. Transcribed interviews were coded by two coders, and themes were generated for each case. Based on the findings, each teacher perceived differently about the theory of evolution and teaching it in Indonesia. A teacher thought that the theory brings a positive value for students, while the other teachers believed that the theory does not contribute much on students' academic and daily life. One teacher overcame the contradiction between evolution and religion through compartmentalization. Moreover, two teachers were found doubting all the evidence of the theory of evolution. The findings are discussed around the alignment issues with existed literature as well as the implication for policy and practices.

P56:

Exploring Culturally Responsive Management and Disciplinary Practices in Pre-Service Teachers' Culturally Responsive Tasks

Sherry A. Southerland, Florida State University

ABSTRACT

African American students, after decades of research, continue to be disproportionately represented in disciplinary action data. Most referrals that lead to exclusionary discipline practices are written by teachers for disruptive behaviors that begin in the classroom. This disciplinary disproportionately and resulting school-to-prison pipeline are arguably rooted in the classroom and must, therefore, be addressed within the classroom. Through features of culturally responsive teaching, science teachers can help mitigate this by providing multicultural lessons and tasks if they can manage the diverse identities of students. Yet, this disproportionality still exists. This raises the pressing need to address teacher's culturally responsive management practices that can enhance or inhibit the engagement of African American students. In this qualitative study, we examine the effect of an African American PST's culturally responsive management practices while implementing three culturally responsive tasks. Our findings highlight the need to expand current conceptualizations of features of culturally responsive teaching to incorporate classroom management.

Strand 12: Educational Technology

Strand 12 Poster Session

4:45 PM-5:45 PM, Exhibit Hall

P57:

Computational Experimentation a Novel Approach in Educational Technology: Analysis of the Science Writing Heuristic

Richard Lamb, East Carolina University
Jing Lin, Beijing Normal University
Brian M. Hand, University Of Iowa
Douglas Hoston, University at Buffalo
Amanda Kavner, University at Buffalo
Jonah B. Firestone, Washington State University Tri-Cities

ABSTRACT

Machine learning algorithms (ML) specifically Artificial Neural Networks (ANNs) are a newer branch of Educational Technology and have been increasingly used in the field of science education for the modeling of outcomes associated with student learning in science. The purpose of this study is to computationally model a potential mechanism of action to explain outcomes seen on the Cornel Critical Thinking Test (CCTT) related to the Science Writing Heuristic (SWH). Student data was examined and developed using Item Response Theory analysis and Cognitive Diagnostics. The neurons of the ANNs develop in five distinct layers of the ANN- input, hidden 1, hidden 2, hidden 3, and output. Results suggest that the system of attributes represented in this computational model are an essential component and the nodes of critical analytical thinking are key.The STAC-MSWH presented here demonstrates the powerful abilities associated with machine learning which allows for the development of complex and dynamic models of systems inside of the elementary classroom.

P58:

Pre-Service Science Teachers' Perceptions of Teaching and Learning After Using Augmented Reality Applications

Denise M. Bressler, University of Pennsylvania
Len Annetta, East Carolina University
Marina Shapiro, California State University, Bakersfield

ABSTRACT

Experts have been arguing for over two decades that schools need to shift their aim—the focus should no longer to be to provide instruction but rather to produce learning. Learning to use technology effectively in the classroom can help teachers make that shift from providing instruction to producing learning. To help pre-service science teachers make that shift, we asked a science methods class to participate in two different augmented reality (AR) activities and then develop a 5E lesson plan integrating an AR activity. Post-interviews were conducted and qualitatively analyzed using the constant-comparative method. Then, this study used epistemic network analysis to assess whether there was a difference in perceptions of teaching and learning between secondary and elementary level pre-service teachers after using AR. The network models were significantly different. Pre-service science teachers who intend to teach at the secondary level had stronger perceptions about teaching content while pre-service science teachers who intend to teach at the elementary level had stronger perceptions about engaging students in learning. Implications for findings are discussed.

P59:

Tracing the Development of a Haptically-enabled Science Simulation (HESSs) for Buoyancy

James Minogue, North Carolina State University
David Borland, UNC - Chapel Hill (RENCI)
Tabitha Peck, Davidson College
Emily Jackson, North Carolina State University
Kern Qi, Davidson College
Niall Williams, University of Maryland, College Park

ABSTRACT

This proposed poster will chronicle the Year 1 efforts of a federally-funded research project that uses an emerging technology, haptically-enabled science simulations (HESSs). Our work integrates the Novint Falcon force-feedback device and the Unity® game engine to create our simulations. We employ our HESSs as a vehicle to isolate and describe changes in teachers' capacity to teach foundational physics concepts. We are interested in the influence of haptic-force feedback on the development of a functional understanding of how their students learn about buoyancy and how to teach it well (Davis, Petish, and Smithey, 2006).

P60:

Using a Faculty-developed Documentary to Communicate Chemistry Research to a High School Audience via YouTube

Stephen R. Burgin, University Of Arkansas
Michelle J. Childress, University of Arkansas
Hassan Beyzavi, University of Arkansas
Yoshie Sakamaki, University of Arkansas

ABSTRACT
This project reports on the development and implementation of a documentary-style film to communicate authentic chemistry research to a high school audience via YouTube. A chemistry faculty member and a science education faculty member at a major research university collaborated on this project. Though we did not document significant gains in content knowledge, the high school chemistry teacher whose students viewed the video believed that the video was of value in introducing his students to the differences between authentic professional research and the sorts of laboratory experiences that they have in his classroom. We believe that the use of YouTube could be a valuable tool in sharing and introducing high school students to the cutting-edge research of professional scientists in their local community.

Strand 13: History, Philosophy, Sociology, and Nature of Science
Strand 13 Poster Session
4:45 PM-5:45 PM, Exhibit Hall

P61:
Exploring Physicists' Views of Scientific Models
Meng-Fei Cheng, National Changhua University of Education
Yi-Wen Huang, National Changhua University of Education
Chien-Yu Lin, National Changhua University of Education

ABSTRACT
This study explored physicists' perspectives of scientific models and modeling processes to suggest new ways to teach the physics modeling curriculum. A total of 10 physicists in Taiwan were invited to participate in the interview. The results show that in terms of the nature of scientific models, the physicists in this study believed that such models should be abstract ideas rather than replicas of target events and involve the use of multiple models for interpreting the same target phenomena. Regarding the functions of scientific models, the physicists in this study proposed that the main functions should be as follows: explanation, prediction, simplification, assisting understanding, description, and visualization. With regard to the evaluation criteria of scientific models, the physicists in this study proposed that the main criteria for evaluating scientific models are as follows: possessing the main functions of scientific models, being consistent with experimental data, being able to explain multiple phenomena, corresponding to existing theories, and using fewer hypotheses. The findings of the study contribute to a better understanding of models and modeling in physics, thereby offering insights and suggestions for curriculum design with respect to modeling in physics.

P62:
Practices, Knowledge, and Nature— Engineering Educators' Views of the Domains of Engineering Literacy
Brian D. Hartman, Walla Walla University
Randy L. Bell, Oregon State University

ABSTRACT
Interest in K12 Engineering has grown in recent years, with engineering literacy being a goal of the NGSS. Because research is limited on appropriate concepts to teach as part of this effort, the goal of this study is to investigate how K12 and university teachers view the domains of engineering literacy: Engineering practices, engineering knowledge, and nature of engineering (NOE). This study

analyzed the results of an open-ended survey completed by 132 educators involved in teaching engineering literacy: Some from K12 classrooms (teachers of science and engineering) and some from academia (professors of science and engineering education). Participant responses were analyzed using a Grounded theory Methodology. Results indicated that participants typically defined engineering practices using terms such as activities, skills, and actions that are employed by engineers. They defined engineering knowledge as including: The engineering method, engineering disciplinary knowledge, and non-engineering knowledge. Many defined the NOE as the discovery of solutions to real-world problems, although one-third of the participants failed to respond to this item. The present investigation seeks to add to the literature on engineering literacy by elaborating the views of K12 teachers and science/engineering professors on the commonly cited engineering literacy components of nature, content, and practices.

P63:

STEM-based NOS teaching on 7th Grade Students' NOS Views

Gunkut Mesci, Giresun University
Eda Erdas, Kastamonu University

ABSTRACT

The aim of the study is to improve 7th grade students' NOS understandings while integrating NOS aspects into the appropriate STEM activities. In this study, four STEM-based contextualized NOS activities are developed during the 4 weeks study. The activities enable students to grasp the relationship between science, engineering, technology, and mathematics by making them feel like scientists, engineers, or inventors. The sample of this study consists of eighteen (10 male, 8 female) 7th grade students. The data are collected pre and post format of the views of NOS questionnaires (VNOS-D), and follow-up semi-structured interviews. Also, the activity, assessment, and reflection essays are collected as additional data. All data are analyzed holistically to generate a profile of respondents' understandings across the targeted aspects of NOS with using content analysis. According to the analyses, 7thgrade students have generally naive views of the targeted NOS aspects before participating in the 4-week study. After STEM-based NOS teaching, a dramatic improvement is observed in their views. All students improve their views of NOS. STEM-based explicit-reflective NOS teaching may be an alternative approach to improve students' NOS views in desired level, and this approach needs to be implemented in different grades and different situations.

P64:

Training the Trainer: An exploration of a future teacher educator's NOS and related pedagogical understandings

Bridget K. Mulvey, Kent State University
Jennifer C. Parrish, University of Northern Colorado
Jeffrey L. Papa, Kent State University
Joshua Reid, Middle Tennessee State University

ABSTRACT

Much research has focused on teachers' and students' NOS understandings, with little to no research identified on science teacher educators. Moving beyond learning about NOS to using it in instruction is a step even more critical for science teacher educators than for science teachers. The present study considers a future science teacher educator's understandings about NOS and how to teach it over time, extending knowledge gained through common pretest/posttest designs. We present a qualitative critical case study of one science education Ph.D. student enrolled in a NOS doctoral course. Given the key role

science teacher educators play in developing NOS understandings and related instruction of K-12 teachers, the current paper examines the pathways of change for a science teacher educator learning these concepts / skills and potential reasons for those changes. Results indicate that there was initial push back against subjectivity and sociocultural influences, with readings such as T. Rex and the Crater of Doom promoting increased understanding. Over time, instructional planning and comments shifted beyond science content to also promote more constructivist and explicit, reflective NOS instruction. Peer teaching--and observing that of others--was identified as a key turning point for NOS instructional understanding.

3/17/20

Concurrent Session 7
8:00 AM-9:30 AM

Publications Advisory Committee
Admin Symposium-How to Get Your Research Published in Science Education Journals PAC Symposium
8:00 AM-9:30 AM, Salon I

How to Get Your Research Published in Science Education Journals PAC Symposium
Catherine E. Milne, New York University
Christina Siry, University Of Luxembourg
Ross H. Nehm, Stony Brook University - SUNY
Gail Jones, North Carolina State University
Troy Sadler, University of North Carolina at Chapel Hill
Kent J. Crippen, University of Florida
Todd Campbell, University of Connecticut
Erin L. Dolan, University of Georgia
Geeta Verma, University of Colorado Denver
Gail Richmond, Michigan State University
Ange Fitzgerald, University of Southern Queensland
Carla Johnson, Purdue University
Sibel Erduran, University of Oxford
Sherry Southerland, Florida State Unversity
John Settlage, University of Connecticut
Lucy Avraamidou, University of Groningen
Sonya N. Martin, Seoul National University

ABSTRACT
The Publications Advisory Committee (PAC) will again be presenting a 'How to get your research published in science education journals' symposium. The symposium is designed to support junior scholars and re-emerging senior scholars interested in learning more about the process for publishing articles in science education journals. Joining us for the symposium are 14 editors/co-editors: journal name and participants are listed in the table below. Journal editors will be dispersed (using name placards) throughout the tables. The contact list below will be available for download by participants. Journal editors will be encouraged to bring business cards, flyers, etc. to hand out to participants. The

symposium will include three roundtable sessions covering the following topics: Choosing the right journal for your paper. An inside look at the review process. The top reasons articles are rejected (and how to avoid them!). We have chosen a roundtable format to allow for small group conversations as journal editors discuss the particular requirements of their journals and provide individual guidance to authors. Participants will be able to move between sessions to varying tables in order for participants to contact specific journal editors. The symposium will wrap up with a closing discussion.

Administrative Session
Sandra Sandra K. Abell Institute for Doctoral Students
8:00 AM-9:30 AM, Hawthorne/Belmont/Laurelhurst
Discussant: Julie A. Luft, University of Georgia, Anna S. Grinath, Idaho State University
Presider: Gregory Rushton, Middle Tennessee State University, Grant E. Gardner, Middle Tennessee State University

Developing the Framework on Categorizing Instructional Approaches of Mathematics Equations in Biology Classrooms
FangFang Zhao, University of Minnesota
Mentor: Stephen B. Witzig, University Of Massachusetts Dartmouth

Developing Knowledge: Sex/Gender Beliefs in Undergraduates and Implications for the Classroom
Katherine Ray King, University of Louisville
Mentor: Stephen B. Witzig, University Of Massachusetts Dartmouth

Navigating Climate Change: Science, Politics, and Learning for Youth
Lynne Zummo, Stanford University
Mentor: Stephen B. Witzig, University Of Massachusetts Dartmouth

How Instructors Model Abstraction in Physical Chemistry
Jessica Karch, Universiity of Massachusetts Boston
Mentor: Gillian H. Roehrig, University of Minnesota

The Patterns of Students' Diagrams And Answers while Solving Force Problems
Judyanto Sirait, University of Leicester
Mentor: Gillian H. Roehrig, University of Minnesota

Examining the Cultural Specificity of Approaches to Learning Biology
Angela N. Google, Middle Tennessee State University
Mentor: Ross H. Nehm, Stony Brook University (SUNY)

An Investigation into the Factors Influencing Acceptance of Evolution across University Instruction
Ryan Dunk, Syracuse University
Mentor: Ross H. Nehm, Stony Brook University (SUNY)

Genetics Knowledge and Belief in Genetic Determinism of Biology and Nursing Stude
Katie Humrick, University of Louisville
Mentor: Ross H. Nehm, Stony Brook University (SUNY)

The Effect of Participation in the Sandra K. Abell Institute on my Dissertation's Theoretical Framing
Jessica Dewey, University of Minnesota
Mentor: Isha DeCoito, Western University

The Elephant in the CURE Classroom: What Do We Know About CUREs Taught by Graduate Teaching Assistants?
Emma Goodwin
Mentor: Isha DeCoito, Western University

Mentoring Structures and the Types of Support Provided to Early-Year Undergraduate Researchers
Gaye Defne Ceyhan
Mentor: Isha DeCoito, Western University

Sketching to Make Sense of Chemical Events at the Sub-Microscopic Levels
Heena Lakhani
Mentor: Femi Otulaja, University of the Witwatersrand

Investigating Science Teachers' Practices on Assessing Students' Understandings of Nature of Science
Wonyong Park, University of Oxford
Mentor: Femi Otulaja, University of the Witwatersrand

Teachers' Indigenous Knowledge and the Possibilities of Integration into Life Sciences Teaching and Learning
Uchechi Agnes Ahanonye
Mentor: Femi Otulaja, University of the Witwatersrand

Trends In K-12 Teacher Agency Research: A Meta-analysis of 10 Years of Science Education Resear
Anica Miller-Rushing
Mentor: Gail Richmond, Michigan State University

What Makes Science Thinkable in High-Needs Elementary Classrooms? Conceptualizations of Elementary Science Teacher Professional Agency
Alison Mercier, University of North Carolina at Greensboro
Mentor: Gail Richmond, Michigan State University

Middle Grade Science Teachers' Learning Reform Based Practices in the Context of Their Physics Content Course
Harleen Singh, Uniiversity of Georgia
Mentor: Gail Richmond, Michigan State University

History of Engineering and Engineering Education
Ezgi Yesilyurt, University of Nevada Las Vegas
Mentor: Gregory Rushton, Middle Tennessee State University

Preparing STEM Graduate Students for Change: A Discursive Approach to the Study of Instructional Reform
Francesca Williamson, Indiana Universiity
Mentor: Greg Rushton, Middle Tennessee State University

Increasing Retention in Graduate Education: Investigating Students' Experiences of Departmental Supports
Ntiana (Diana) Sachmpazidi, Western Michigan University
Mentor: Greg Rushton, Middle Tennessee State University

Factors Influencing Group Interactions While Constructing Explanations Using the CEJ Framework in a Diverse Setting
LaShawn McNeil, University of Georgia
Mentor: Noemi Waight, University at Buffalo

The Conceptual Profile of Substance as a Powerful Tool to Characterize Shifts in Learning Chemistry in Student's Ways of Speaking and Thinking about Substance
Raul Orduna Picon
Mentor: Noemi Waight, University at Buffalo

Relationships Between Students' Scaffolded Small-Group Discussions and their Written Scientific Explanations
Timothy G. Klavon, Temple University
Mentor: Noemi Waight, University at Buffalo

Strand 1: Science Learning, Understanding and Conceptual Change
New approaches to Learning
8:00 AM-9:30 AM, Salmon
Presider: Calvin S. Kalman, Concordia University

Comparison of Labatorials with Traditional Physics Laboratories
Calvin S. Kalman, Concordia University
Franco La Braca, Concordia University
Mandana Sobhanzadeh, Mount Royal University

Dialogical argumentation and assessment for learning: Closing the gap in the science classroom
Frikkie George, Cape Peninsula University of Technology
Keith R. Langenhoven, University Of the Western Cape

Using Mind Maps to Determine Students Knowledge Dimensions on Disciplinary and Interdisciplinary Core Ideas
Helen Semilarski, University Of Tartu
Regina Soobard, University Of Tartu
Miia Rannikmae, University Of Tartu

ABSTRACT
During the NARST 2020 annual conference, scholars will share their work with the NARST community in a dedicated poster session. In this session, scholars will discuss their work, new updates since the institute, and a reflection on what they learned at the institute. This poster session will begin with a brief 1-minute lightning talk from each scholar to highlight their poster followed by a standard poster

session.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Epistemic aspects of engagement in novel contexts of learning physics
8:00 AM-9:30 AM, Mt Hood
Discussant: Edit Yerushalmi, Weizmann Institute of Science, Israel
Presider: Elon Langbeheim, Ben-Gurion University, Israel

Epistemic aspects of engagement in novel contexts of learning physics
Elon Langbeheim, Ben-Gurion University, Israel
Anna M. Phillips, Cornell University
Natasha G Holmes, Cornell University
David Brookes, Florida Internation
Shulamit Kapon, Technion - Israel Institute of Technology
Edit M. Yerushalmi, Weizmann Institute of Science, Israel
Samuel Safran, Weizmann Institute of Science, Israel
Maayan Schvartzer, Technion - Israel Institute of Technology

ABSTRACT
The proposed symposium will focus on engagement in physics learning that goes beyond the ordinary school/university context. We will discuss epistemic aspects of learning in "reformed" learning contexts, such open-ended labs, computational courses or extended project courses at the advanced high school or college levels. Each presentation describes a different epistemic aspect of engagement in learning physics in light of the physics community's commitment to theory-based quantitative models. The first presentation discusses student's internalization of the hierarchical, epistemic structure of physics knowledge that emphasizes, formal mathematical modeling. The second describes students' development of epistemic agency that may promote or hinder their interpretation of discrepant experimental results. The third presentation describes the role of teaching that makes epistemology explicit in a studio-based college course and the last describes teaching that harnesses qualitative reasoning to cultivate an anticipation for quantitative models

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Early Childhood Engineering: Supporting Engineering Design Practices with Young Children and Their Families
8:00 AM-9:30 AM, Eugene
Discussant: Monica Cardella, Purdue University
Presider: Scott A. Pattison, TERC

Early Childhood Engineering: Supporting Engineering Design Practices with Young Children and Their Families
Scott A. Pattison, TERC
Monica E. Cardella, Purdue University
Hoda Ehsan, Purdue
Smirla Ramos-Montañez, Oregon Museum of Science and Industry
Gina Svarovsky , University of Notre Dame
Merredith D. Portsmore, Tufts University
Elissa Milto, Tufts University

Mary McCormick
Chris San Antonio-Tunis, Museum of Science, Boston

ABSTRACT
Engineering is a critical yet understudied topic in early childhood. Previous research has shown that even young children can engage in (versions of) engineering design practices and processes that are similar to those of adult engineers and designers. In this session, we will share and discuss current research projects to explore how different in-school and out-of-school contexts and activities support 3- to 8-year-old children as they engage in engineering design. We will consider ways that the different characteristics of the activities and spaces, as well as the practices of teachers, facilitators, and parents, make space for and encourage engineering design thinking.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Engaging Young Children in Science and Engineering Practices: Approaches to Research and Design

8:00 AM-9:30 AM, Meadow Lark/Douglas Fir - 3rd floor
Presider: Eve Manz, Boston University Wheelock College of Education & Human Development

Dance-STEP: Collective Embodied Science Models and the Particulate Nature of Matter
Chris Georgen, Boston University Wheelock College of Education & Human Development

Using Iterative Co-Design to Develop Classroom Empirical Activity
Eve Manz, Boston University Wheelock College of Education & Human Development
Betsy Beckert, Boston University Wheelock College of Education & Human Development

Kindergarten playground collisions: Reconceptualizing gravity as a necessary intellectual resource
Michelle Salgado, University of Washington
David Phelps, University of Washington

Considerations when Engaging Young Learners in Scientific Modeling for Sense-making
Christina V. Schwarz, Michigan State University
Eve Manz, Boston University Wheelock College of Education & Human Development

ABSTRACT
Realizing a vision of science-as-practice in K-12 classrooms has been a major focus of science education research and design efforts in the last decade. In this paper set, we use our current research studies as a context for a conversation about approaches to understanding, designing for, and supporting the science and engineering practices in the primary grades (Kindergarten - Grade 2; ages 5-8). We explicate our commitments to designing meaningful contexts for students to engage in practices and leveraging young children’s strengths, interests, and questions. We show how these commitments guided the four research studies and describe findings related to new understandings of young students’ resources for practices and new approaches to supporting meaningful engagement in science practices in the primary grades. This session will also involve an opportunity for participants to share approaches and questions in small group discussion.

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

Dialogic instruction and sense-making of science concepts

8:00 AM-9:30 AM, Salon E

Presider: Tara M. Nkrumah, Arizona State University

Science Teaching at the Instructional Core: Opportunities for Students' High-Level Thinking and Sensemaking

Miray Tekkumru Kisa, Florida State University
Ozlem Akcil Okan, Florida State University
Zahid Kisa, Florida State University

ABSTRACT

Understanding the instructional factors that support students' high-level thinking and sensemaking can support achieving the vision of the recent instructional reforms in science education by addressing low academic rigor observed in many science classrooms today. To that end, prior research tends to foreground either the curriculum or the teachers' practices or solely focus on the students to explain their sensemaking processes. We propose a more comprehensive view of teaching that focuses on the interaction among the teacher and students around the instructional task, which provides a context for student thinking. With this lens, we explored how students' high-level thinking and sensemaking is (or is not) maintained throughout the trajectory of a science lesson. By examining the implementation of the same lesson across three different classrooms, our analysis revealed how the interaction of teachers' practices, students' intellectual engagement, and a cognitively demanding task together support rigorous instruction. Our analysis also shed light on the factors that support rigorous and responsive opportunities for student learning throughout the trajectory of a science lesson. This study has important implications for improving and assessing instruction and would support the recent instructional improvement efforts to facilitate a 3-dimensional vision for science teaching.

Teacher learning and planning for epistemic agency in storyline discussions

Kevin Cherbow, Boston College
Katherine L. McNeill, Boston College

ABSTRACT

Storyline curricula can position students with the epistemic agency to figure out phenomena and build scientific ideas. In storylines, sensemaking discussions (initial ideas, building understanding, consensus) are important epistemic tasks for students because they are the main venue for public knowledge-building across a storyline. Therefore, we employed a situated and responsive professional learning environment to facilitate teacher planning, enactment, and reflection on these storyline discussions to better distribute epistemic agency to students. This study examined pre- and post-interviews and four discussion planning cycles from one middle school science teacher. Our analysis focused on identifying episodes of pedagogical reasoning (EPRs) related to epistemic agency in discussions. These EPRs were then analyzed to develop themes about the teacher's understanding of epistemic agency as a pedagogical construct. Initially, the teacher characterized the knowledge-work present in each discussion type as similar in form and worked to iron out uncertainty in discussions. As he continued planning, he came to better understand the epistemic purposes of each discussion and the role of uncertainty in opening up epistemic space for students in discussion. Therefore, we believe that the

planning cycle can support teachers to attend and respond to the emergent epistemic curriculum in storyline discussions.

Using cogenerative dialogues to help teachers support meaningful and coherent sensemaking through consensus
Abraham Lo, BSCS Science Learning

ABSTRACT
Science reforms involve students using scientific and engineering practices to construct disciplinary knowledge with others. Researchers have argued that students' engagement in scientific practices should be meaningful so that students understand how and why their decisions would help them accomplish their scientific goals. In addition, learning should be coherent from the students' perspective, meaning that learning experiences are sequenced to build on student ideas and allow students to connect ideas within and across disciplines to explain natural phenomena. This paper presents research that involves classroom stakeholders (the teacher, students, and researcher)engaging in cogenerative dialogues to co-construct understandings of classroom events and share responsibility for developing and carrying out solutions to improve student learning. We used a framework composed of important epistemic issues related to supporting student learning that is meaningful and coherent from the students' perspective. Through these co-generative dialogues, the teacher and students learned to notice key aspects of classroom practice that were hindering the student's knowledge-building role and work. This research makes visible the challenges of enhancing the students' knowledge-building role and the challenges involved in promoting the desired shifts.

Strand 5: College Science Teaching and Learning (Grades 13-20)
The Impact of Chemistry Education Research on Theory Development, Classroom Improvements, and Pre-Service Teacher Training
8:00 AM-9:30 AM, Salon D
Discussant: Anita Schuchardt, University of Minnesota

Modeling the influence of a constructivist learning environment in diverse chemistry courses
Regis Komperda, San Diego State University
Anita Schuchardt, University of Minnesota

Understanding how active learning catalyzes students' attitudes and understanding of chemistry
Paulette Vincent-Ruz, Learning Research and Development Center
Christian D. Schunn, University of Pittsburgh
Anita Schuchardt, University of Minnesota

Measuring theoretically grounded aspects of chemistry identity
Kathryn Hosbein, East Carolina University
Jack Barbera, Portland State University
Anita Schuchardt, University of Minnesota

What can university science faculty learn about teaching through engaging in curriculum design with K12 Teachers?
Jeffrey Spencer, University of Michigan at Ann Arbor
R. Charles Dershimer, Greenhills School

Ginger V Shultz, University of Michigan at Ann Arbor
Anita Schuchardt, University of Minnesota

Assessment of Undergraduate Students Participation in the Science Practice in Transformed Laboratory Courses

Joi P. Walker, East Carolina University
Anita Schuchardt, University of Minnesota

ABSTRACT

Chemistry Education Research (CER) is a sub-discipline of chemistry that aims to answer questions about chemistry teaching and learning by integrating ideas from other fields such as education, cognitive science, and social psychology. However, the impact of CER is not limited only to the practices that a practitioner does in their classroom. Contributing to the research field requires “an engagement with the current state of knowledge, shared concepts and accepted methodologies in the field” (Taber, 2015). The objective of this session is to showcase the different ways in which current research in Chemistry Education has developed to support pre-service teacher training, intervention development and assessment, and the development of attitudinal and learning theory. By sharing this work as a group, we hope to contribute to the further development of chemistry education research programs and engage in conversation to other sub-fields of DBER Taber, K. S. (2015). Advancing chemistry education as a field. Chemistry Education Research and Practice, 16(1), 6-8.

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

Student understandings and perceptions of evolution

8:00 AM-9:30 AM, Salon C

Presider: Grace Elizabeth Baker, Western Washington University

College Student Understanding of Extinction & Natural Selection in the Anthropocene

Yael Wyner, City College Of New York, City University of New York, New York, NY
Rob DeSalle, American Museum of Natural History, New York, NY

ABSTRACT

In the midst of the planet’s 6th mass extinction event, we examined how undergraduate biology students (n=137) understand the relationship between extinction and natural selection. We found that even after completing units on extinction and natural selection, the majority of students misattributed the threatened status of the panda (48%), the extinction of a hypothetical plant (59%), and the dinosaur extinction (64%) to natural selection. The relationship between these aspects of evolution must be better articulated and communicated to prevent students from misunderstanding and misusing evolutionary theory to explain today’s human-caused 6th mass extinction event in the history of life on Earth. Instructing on the differences between natural selection and extinction and highlighting the role of bad luck and catastrophic environmental change in historic and modern day extinction is crucial for educating about evolution and extinction in the Anthropocene.

How to read the tree of life: investigating factors influencing the ability to read evolutionary trees

Thilo Schramm, University Duisburg-Essen
Philipp Schmiemann, University of Duisburg-Essen - Biology Education

ABSTRACT
Evolutionary trees are the most important form of representation in communicating evolutionary processes and act as hypothesis of taxonomic relationships. In formal and informal learning environments, they are seen as an indispensable tool in understanding evolutionary concepts. Despite the relevance of the ability to read evolutionary trees (called tree-reading), students at all educational levels struggle with correctly reading and interpreting them. To enhance public understanding of evolution in general, it seems to be inevitable to address tree-reading abilities. As there are scarcely any findings on how tree-reading is linked to other constructs, we investigate the relationship between tree-reading and acceptance of evolution (MATE), knowledge about evolution (CINS) and spatial thinking (paperfolding) in a sample of (under-)graduate students (n=455) from four universities. Significant correlations between all three control variables and tree-reading skills could be found with medium effect sizes. Furthermore, a correlation between tree-reading skills and high school graduation mark could be found, but no effect of gender on the tree-reading abilities. Findings of this study can be used in formal and informal educational settings to improve teaching tree-reading and using phylogenies as communication tools by helping to decide which information should presented along the diagram.

Moving between Contexts: a Pedagogical Intervention's Effects on Community College Biology Students

Kathryn Green, University of Georgia
Cesar Delgado, North Carolina State University
Brandon Foster, Wake Technical Community College

ABSTRACT
Evolution is an essential underlying concept in biology. Previous research demonstrates that obstacles inhibit successful teaching and learning about evolution. One obstacle is the existence of a worldview that denies evolution as the best explanation for the diversity of life on Earth. In an attempt to surmount that obstacle, this study designed an intervention using the cultural border crossing (CBC) theoretical framework. CBC posits that learners might encounter extensive differences between their home cultures and the science classroom culture and may need assistance navigating these cultural borders. The intervention included four mini-lessons designed to alleviate tension for students crossing cultural borders between scientific and religious worldviews while learning about evolution. Qualitative data used to determine how this intervention affected students’ understanding and acceptance of evolution is discussed in this paper. Qualitative results indicated that most students' understanding of evolution changed, although not always in an accurate manner. In addition, two themes which emerged related to evolution acceptance will be detailed in this paper. Results call for further research on how students’ cultures influence their learning about evolution and how educators can best facilitate learning among students with various cultural beliefs about the diversity of life on Earth.

Students' perspectives on their acceptance of evolution

Ryan D.P. Dunk, Syracuse University
Jason R. Wiles, Syracuse University

ABSTRACT
A recent review of evolution education by 20 prominent scholars in the field suggest that researchers of evolution acceptance should focus on work geared towards determining the generalizability of known results and investigating evolution acceptance across a longitudinal framework. Here, we take up that challenge by exploring qualitatively how students perceive changes in their acceptance of evolution throughout their higher education experience. Overall, we found that students have difficulty articulating changes in their attitudes over time, even when quantitative data shows significant changes.

However, students were able to note and consider some changes, especially when contrasted with their experience before high school. We further found that students tended to rely on knowledge of evolution and religious beliefs to describe their attitudes towards acceptance of evolution. Notably, even when presented with the suggestion, our student participants were unable to explicate any possible ways that their understandings of the Nature of Science influenced their acceptance of evolution. Students were more easily able to articulate how their knowledge of evolution and religious beliefs influenced their acceptance of evolution. This work adds important qualitative data and insight into student's reasons for their acceptance or rejection of evolutionary biology.

Strand 6: Science Learning in Informal Contexts

Science interest and identity formation in informal spaces

8:00 AM-9:30 AM, Salon F

Presider: Scott Byrd, Maine Mathematics and Science Alliance

DHH Students Making Connections across Gaps between Formal and Informal Science Learning Spaces

Scott Cohen, Georgia State University
Patrick J. Enderle, Georgia State University
Jessica Scott, Georgia State University
Maggie Renken, Georgia State University

ABSTRACT

Science-specific support in both formal and informal contexts can have a critical impact on the life trajectories of Deaf and Hard of Hearing (DHH) learners. Many DHH students find themselves underprepared to pursue STEM majors in postsecondary education and struggle to move on to STEM careers upon graduation. To support DHH students in the readiness of skills related to STEM fields, it is necessary to provide them with appropriate and accessible opportunities in informal science education to accentuate, and indeed, enhance their science learning trajectory in more formal spaces. Drawing from a larger, ongoing research study, we are concerned with better understanding adolescent DHH students who participate in a summer STEM camp and their formal science education. A challenge that several students, including our focal cases, identified as limiting their connectedness to STEM came from how they viewed the learning experiences they had in their formal science classrooms. Potential exists to harness informal science education to improve DHH students' science learning. This presentation will highlight the connections and potential that DHH students' see for both formal and informal science learning contexts.

I'm Fine With Just Collecting Data: Engagement Profiles Differ in Citizen Science

Till Bruckermann, IPN – Leibniz Institute for Science and Mathematics Education
Hannah Greving, Leibniz-Institut für Wissensmedien (IWM)
Ute Harms, IPN – Leibniz Institute for Science and Mathematics Education

ABSTRACT

Digital technologies facilitate collaborations between citizens and scientists in Citizen Science (CS) projects. Besides the facilitation of data transmission and access, digital technologies promote novel formats for education in CS by including citizens in the process of gaining and discussing evidence from data. Citizens presumably profit more from CS if they are able to participate in the whole scientific process. However, citizens' actual engagement has not been analyzed yet depending on scientific activities. Therefore, we investigate how citizens actually engage in different scientific activities (i.e., data collection and analysis) in an online-based CS project. Behavioral patterns of engagement for N=141 participants were analyzed through activity logs in between-projects and within-project comparisons. The results indicate that inquiry-led platforms increase citizens' commitment to CS projects, but it is the opportunity to contribute their own data that encourages citizens to engage in activities. The significance of participants' role (i.e., contributing own data) refines previous findings. Designing inquiry-led CS projects does not necessarily lead to higher cognitive engagement because participants' motivations to engage in specific activities differ. Hence, citizens need support to change their role from data collector to data inquirer, beside the support with scaffolding tools for the inquiry process.

Participating in the scientific publication process: Expanding students' perceptions of scientific inquiry and identity

Sarah Fankhauser, Oxford College of Emory University
Gwendolynne Reid, Oxford College of Emory University
Gwendolyn Mirzoyan, Emory University
Clara Meaders, Cornell University
Olivia Ho-Shing, Harvard University

ABSTRACT

Communication is an essential component to scientific inquiry, and specifically the primary literature is highly valued by scientists. Yet, the role of primary literature within scientific inquiry is generally absent from the science classroom. In this study we examined how middle and high school student perceptions of scientific inquiry changed after they engaged in a peer-review and publication process of their research papers. We interviewed twelve students who published their papers in the [Journal], a science journal dedicated to publishing the research of middle and high school students. Students reported a broader understanding of scientific inquiry, and explicitly recognized the important roles of effective communication, revision, and collaboration in doing science. While not all students will be motivated to publish their research, our work has important implications for how the concepts of peer-review and publication should be integrated into disciplinary literacy and scientific inquiry.

Reasons for Teenagers to continuously volunteer in an informal science program.

Sapir Salamander, Ben-Gurion University Of the Negev, Israel
Orit Ben Zvi Assaraf, Ben-Gurion University Of the Negev, Israel
Netzach Farbiash

ABSTRACT

Our study focuses on an informal science program in a science museum, which promotes social leadership by providing a firm basis for young people to study science, physics and astronomy while fostering personal and social growth. The main aim of this study is to explore the teenagers' narrative-self and their science identity's components. Students who participate in this program practice and teach science to younger kids every week for 4 years. Therefore, we investigated the reasons teenagers chose to commit to the program. In order to do so, we interviewed 17 participants aged 15 to 16 years old, in a semi-constructed interview. A thematic analyzing method was used in order to identify and analyze the teenagers' reasons for volunteering, their self-narratives and science identity's components. Data from the semi-structured interviews underwent thematic analysis. The results of this study show that the volunteering teenagers receive positive feedback from their social surroundings for participating in this program, and it positively affects their aspirations to keep engaging in science and in

this program as a whole. This study shows how the sense of belonging to the program's science community influences youths' persistence in science.

Why Some Persist: A Case Study of Six Girls' Development of Interest in Science

Stephanie Rafanelli, Stanford University Graduate School of Education

ABSTRACT

This paper offers a case study analysis of the social experiences of six high school girls in the Bay Area who participated in an extracurricular science program. Using frameworks of interest development and behavior, this study explored the social climate and collaborative learning factors that supported each girl's ongoing participation. Opportunities for short-term collaboration with new peers were most important to participants in earlier stages of interest development. In contrast, opportunities for ongoing collaboration with consistent team members were identified by participants in later stages of interest development. A sense of belonging and lack of STEM Stereotypes were salient to all. Data offer implications for program designers of adolescent science activities and future research.

Strand 7: Pre-service Science Teacher Education

Informal Science Education and Socioscientific Issues

8:00 AM-9:30 AM, Salon A

Presider: Joanne K. Olson, Texas A&M University

Developing practice across contexts: Examining long-term impacts of pre-service teacher internships within an informal setting

James F. Kisiel, California State University, Long Beach

ABSTRACT

This mixed-method investigation examines long-term impacts of an internship program that placed pre-service teachers as educators several informal science education institutions in Southern California. We were interested to see the extent to which participation in the communities of practice inherent in the informal science education (ISE) institutions might contribute to the development of tools, strategies and goals that were consistent with the community of practice that might prevail within a school setting. This study examined the experiences of 27 pre-service teachers from an urban state university who engaged in an 8-10 week internship with one of three informal science institutions. A mixed method analysis including post-program interviews and online survey responses obtained up to four years after completion of the program were used to understand the benefits of the internship experience. Overall, former interns attributed their experiences working as informal science educators as contributing to strengths in their current classroom practices, pointing to key similarities in the practices of both formal and informal educators.

A Place-Based Education Analysis of Pre-Service Teachers Images of Science Instruction in Informal Settings

Karthigeyan Subramaniam, University Of North Texas
Christopher S. Long, University of North Texas
Pamela Harrell, University Of North Texas

ABSTRACT
This study investigated prospective teachers' images of science instruction in informal settings using the place-based education framework (Sobel 2004). Images refers to the experiential understanding of science instruction in informal settings constructed from 12 years of conventional classroom education. Place-based education refers to instruction situated within an informal setting that connects the contexts of school, and the ecological, social and cultural contexts of the informal setting through authentic purposes for the learning of content. Drawings and narratives from 186 participants collected before the commencement of an elementary science methods course served as the data to explicate the prospective teachers' images of science instruction in informal settings. Data analysis indicated that participants' images of science instruction in informal settings (1) had content focused explicitly on the ecological aspects of a place, (2) included ecological learning, and dynamic learning, and (3) provided students with direct and guided experiences of the natural phenomenon within the place instead of just mediated experience. This study indicated that the place-based education framework can provide frames to view prospective teachers' images as complex scripts for teaching science in informal settings.

Elementary Preservice Teachers' Perceptions of Facilitating Socioscientific Issues

Melanie Kinskey, University of South Florida
Dana L. Zeidler, University Of South Florida

ABSTRACT
Socioscientific issues (SSI) have been found to improve scientific literacy skills among K – 12 students. Elementary preservice teachers (PSTs), however, are reluctant to implement SSI due to a lack of confidence with content knowledge concerning SSI and pedagogical abilities. Existing research focuses on helping PSTs overcome these concerns through microteaching, adapting existing curricula, and experiencing SSI through methods courses. While it has been noted that formal preparation is required for PSTs to feel confident in their abilities to facilitate SSI, little has been done to prepare elementary PSTs to facilitate SSI during field experiences. PST's concerns regarding science instruction with SSI is speculative since existing empirical evidence has been collected outside the context of the classroom. In this study, we examine elementary PSTs experiences as they facilitated SSI in the classroom. Community of practice (CoP) meetings provided formal training to prepare these elementary PSTs to facilitate SSI. Recordings of the CoP meetings, lesson plans, observations, and interviews served as data sources. Analysis revealed multiple perceived challenges identified by the elementary PSTs that impacted their ability to successfully facilitate SSI. Among these were allocated science instruction time, student behaviors, and congruence between an activity, science content and issue.

Socio-scientific issues as tools for improving environmental knowledge, skills, and behavior in pre-service education

Anat Abramovich, Malam Headquarters Israeli Center for Scientific Technological Education Techn
Shirley Miedijensky, Technion, Israel Institute Of Technology
Yael Shwartz, The Weizmann Institute Of Science

ABSTRACT
This study assessed the environmental qualifications (e.g., knowledge, skills, behavior) of pre-service primary science teachers, assuming this could predict their willingness to deal with education for sustainability (EfS) in their future science lessons. Socio-scientific issues (SSI) were chosen for assessment and to arouse interest. A total of 44 pre-service science teachers participated in the study, which included questionnaires to assess the participants' environmental qualifications both at the beginning and end of the year. In between, participants were asked to deal with three (out of five) SSI

given in a course forum and provide written reflections on the process. Mixed method research encompassed content analysis of responses from both questionnaires and descriptive analysis of participants' reflections. Findings show an improvement in participants' environmental qualifications and suggest that dealing with SSI affected their deep understanding of environmental issues, improved their environmental behavior, and led them to embrace SSI as a potential teaching tool for introducing environmental issues to their future students. The conclusion was that introducing SSI among pre-service primary science teachers, even as a course task, might stimulate environmental interest and initiate willingness to act in favor of the environment and implement EfS in the classroom.

Strand 7: Pre-service Science Teacher Education

Shifting the Teaching Paradigm

8:00 AM-9:30 AM, Salon B

Presider: Claire Cesljarev, Indiana University

Preservice Elementary Teachers' Intensive Field Experience at a Science Summer Program: Effects on Self-efficacy

Jacquelyn Duran, Teachers College, Columbia University
Alison Matthews, Teachers College Columbia University
Allison Bookbinder, Teachers College, Columbia University
Min Jung Lee, Teachers College, Columbia University

ABSTRACT

Elementary teachers' science teaching self-efficacy is affected by their own experiences of learning science, or they feel they lack adequate preparation to teach science (Knaggs, & Sondergeld, 2015; Settlage, Southerland, Smith & Ceglie, 2009; Bleicher & Lindgren, 2005; Ramey-Gassert, Shroyer & Staver, 1996). A hands-on, inquiry-based summer science program for elementary children (or "science camp") is a unique context in which preservice teachers are given the opportunity to refine their science teaching practice on a daily basis while being supported by inservice co-teachers within the classroom. Our study seeks to understand how these experiences at science camp shape preservice teachers' beliefs about their ability to teach science. Individual interviews and surveys were administered both prior to camp and at the end of camp, to explore their science teaching self-efficacy and their experiences learning and teaching science. In addition to our own survey instruments, we also administered the STEBI-B (Riggs & Enochs, 1990) before and at the end of camp. Study participants were 16 preservice elementary teachers who taught at this science camp for the first time. During this session, we will share our data that was collected in the month of July.

Changes in Pre-Service Teachers' Orientations Towards Teaching - A Four-Year Case Study

Stefan Sorge, IPN - Leibniz Institute for Science and Mathematics Education, Kiel

ABSTRACT

In this paper, I examine the development of four pre-service physics teachers' orientations towards teaching science throughout four years of university teacher education. Orientations towards teaching science work as filters of information and guidance for teacher's actions. To capture the orientations towards teaching, the following dimensions should be addressed comprehensively: conceptions 1) of science teaching and learning, 2) about the nature of science (NoS) and 3) about the goals or function of science education. Pre-service teachers enter teacher education with already developed conceptions about teaching based on their own experiences as students. Previous research provided conflicting results to which extend orientations can be altered throughout teacher education. In the present study, I followed a mixed-method approach to 1) define profiles of using a larger data set, 2) describe the development of each pre-service teacher, and 3) compare their development. Three different developmental paths could be identified. Two pre-service teachers showed stable orientations across all four years. One pre-service teacher with some field experiences altered orientations throughout the years, ending with a traditional orientation. The fourth pre-service teacher developed more reform-oriented orientations without field experiences. Possibly influencing factors and implications for the design of university teacher education are discussed.

Development of Beginning Teacher's Understanding of Students, Learning and Assessment: A Longitudinal Study
Enrique Pareja, Truman State University

ABSTRACT
This study focused on the development of specific aspect of beginning teacher Pedagogical Content Knowledge (PCK) in an Alternative Certification Program. Data was collected throughout the program and into the first two years of teaching, including interviews, classroom observations and participant reflections. Profiles constructed for each case and subsequent cross-case analysis revealed that participants shifted their beliefs about students as learners and assessment based on the influence of the context under which they were developing at each point in time. Participants would resolve any conflict arising with new views presented to them in a subjective manner, prioritizing coherence with their prior knowledge on the specific aspect of PCK. These findings provide an alternative perspective on the nature of the shift in knowledge that occurs during teacher preparation and the initial years of teaching. It allows us to provide a different angle on the dynamics among PCK components based on the interaction among these as they develop over time. Moreover, they allow us to see that this development is neither linear nor unidirectional. Additionally, it shows us that teachers constantly revalue their views of students as learners and assessment based on the experiences provided by both their academic and professional context.

Development of Resident Teachers' Noticing Skills Prior to Student Teaching
Amity F. Gann, Temple University - College of Education
Janelle M. Bailey, Temple University

ABSTRACT
This multiple case study of six resident teachers during the first half of their yearlong teacher residency explores how residents learn the pedagogical skill of noticing student thinking. Residents were matched with experienced mentors with varying teaching orientations and tendencies to use noticing skills in their own practice. Data included interviews, observations, and artifacts, and were analyzed with both a priori codes and an open-coding process. These cases suggest that resident teachers' abilities to engage with and learn student-centered practices are largely a reflection of their personal teaching orientations combined with their mentors' teaching orientations and prioritization of the use of student-centered practices. For example, regardless of a resident's initial interest in using student-centered practices, if their mentors were student-centered or modeled responsive teaching skills, the resident teacher was more apt to take up these skills. However, if paired with teacher-centered mentors, even those residents with strong inclinations toward student-centered instruction demonstrated little to no improvement in use of noticing practices. This study suggests that teaching orientation and inclination toward using noticing skills are important attributes to consider when selecting mentors.

Strand 8: In-service Science Teacher Education

Professional Development using Computational Thinking and Robotics

8:00 AM-9:30 AM, Pearl

Presider: Todd L. Hutner, The University of Alabama

Engage Teachers as Active Co-Designers to Integrate Computational Thinking in STEM Classes

Sally PW Wu, Northwestern University
Gabriella Anton, Northwestern University
Connor Bain, Northwestern University
Amanda N. Peel, Northwestern University
Michael Horn, Northwestern University
Uri Wilensky, Northwestern University

ABSTRACT

To help high school teachers engage their students in the NGSS practice of computational thinking (CT) in STEM classes, teachers must receive training in computational practices and tools, particularly regarding how to integrate CT in their STEM classes. We provided such training in a four-week professional development that positioned eight teachers as co-designers of CT-STEM curriculum in teams with researchers. In this paper, we investigate whether the professional development and co-design process help teachers develop an understanding of computational practices for CT in STEM and feel confident in teaching CT-STEM practices. A pre-post survey showed that all teachers gained understanding of and confidence in teaching CT-STEM practices, particularly in computational data practices. Further, a weekly survey showed that teachers felt overwhelmed at the beginning, but that engaging in co-design with researchers helped teachers grow more confident and enthusiastic about the CT-STEM curricula that they developed. Our findings illuminate what aspects of our professional development helped teachers integrate computational practices and tools into their science curriculum as well as processes that contributed to teachers' confidence in teaching CT. We will share insights on difficulties that teachers may face and the potential of integrating CT for teachers and students in science classes.

Secondary science teachers conceptualizations of computational thinking and perceived barriers to CT/content integration

Vance J. Kite, North Carolina State University
Soonhye Park, North Carolina State University

ABSTRACT

Scholars contend that computational thinking (CT) is a foundational component of 21st-century work. Consequently, many advocate for engaging all students with CT practices. Historically, CT education has been confined to computer science courses; which have not been widely available and are often composed of White males. To broaden the range of students exposed to CT, these practices must be integrated with disciplinary content in core curricula, such as science. Achieving this fusion, however, depends upon the creation of professional development (PD) programs to support teachers in this work. An important first step towards this goal is to identify areas where teachers need professional support by building an understanding of science teachers' existing conceptualizations of CT and their perceived barriers to CT/content integration. To address this need, we conducted a survey study focusing on secondary science teachers' conceptualizations of CT and their perceived barriers to CT/content integration. Analysis of 123 completed surveys reveals that only a quarter of teachers have accurate CT

conceptualizations, that teachers often view CT as “thinking like a computer”, and that CT PD improves teachers’ conceptualizations. Additionally, a majority of teachers identify lack of CT understanding as the biggest barrier to CT/content integration.

Teaching Science, Math, and Coding using Collective Argumentation: A Case Study of One Teacher's Implementation

Anna Gillespie-Schneider, University Of Georgia
Barbara A. Crawford, University Of Georgia
AnnaMarie Conner, University Of Georgia
ChanMin Kim, Pennsylvania State University
Roger Hill, University Of Georgia
Timothy Foutz, University Of Georgia
Sidney Thompson, University Of Georgia
David F. Jackson, University Of Georgia

ABSTRACT
The focus of our work involves creating an innovative approach for elementary teachers to teach children how to code and learn science and mathematics and engage in inquiry and critical thinking. We call this approach <blinded for review>. The approach addresses the need to develop teaching practices that integrate the teaching of coding with the standard practices used to teach other curricular content. Our teacher professional development work takes place in the United States with teachers of upper elementary students. To develop the approach the team built on recent literature related to argumentation, coding and integrated science and mathematics learning. The Research Questions driving this research included: 1) what are teachers’ beliefs about argumentation in mathematics, science, and coding; 2) how do participants enact lessons based on the approach in their classrooms? Participants in this qualitative study included a cohort of 14 elementary school teachers from a participating school district. We focused on teachers’ beliefs about mathematics, science, coding, and argumentation, and we developed a case study of one selected teacher enacting the approach. Findings suggest instructional methods generated from this study will be relevant to other professional development programs.

Using Teacher Narratives of Integrating LEGO Robotics as Assessment Tools and Evidence of Professional Learning

Adam Devitt, California State University, Stanislaus

ABSTRACT
We embrace the call for classroom teachers to prepare students for STEM fields by innovating curriculum and instructional practices that integrate robotics into middle school math and science lessons. Our study investigates nuanced ways to document and assess student learning in response to research that advocates the need to forefront student prior knowledge, abilities, and personal curiosities. We content that teacher narratives demonstrate potential to capture quality student learning, and at the same time become a conduit for teacher professional learning. In our professional development, teachers learned pedagogy, programming, LEGO Robotics, and collaboratively designed lessons for their classrooms as ‘design-partners’. Using frameworks for student learning and professional practice, we analyzed video of teachers’ narratives from integrating robotics lessons during the school year. Our framework highlights critical, complex, and dynamic evaluations and decision-making practices as teachers designed and implemented lessons using robotics and weaving in student curiosities and personal abilities.

Strand 10: Curriculum, Evaluation, and Assessment

Analysis and Evaluation of Science Curricula

8:00 AM-9:30 AM, Columbia

Presider: Gyeong-Geon Lee, Seoul National University

Evaluating Computational Modeling Curriculum through Students' and Teachers' Perspectives: Insight into Enacted and Experienced Curriculum

Arif Rachmatullah, North Carolina State University
Danielle C. Boulden, North Carolina State University
Jennifer Houchins, North Carolina State University
Bita Akram, North Carolina State University
Nicholas Lytle, North Carolina State University
Veronica Cateté, North Carolina State University
Tiffany Barnes, North Carolina State University
Eric N. Wiebe, North Carolina State University

ABSTRACT

The importance of incorporating computational thinking into science learning is increasingly being recognized in the science education literature, leading to the development of curricular materials that encompass this integration. This study examined the evaluation of two parallel integrated CT and science learning curricula, traditional and Use-Modify-Create (UMC), utilizing Porter's Assessment Framework and focused on the enacted and experienced curriculum. A total of 139 middle-grade students and their four teachers participated in the study. Students' responses to an open-ended question asking their perceptions of what they learned from the lessons were collected. Interviews were also conducted with the teachers. Semantic Network Analysis (SNA) was used to analyze students' responses. The results indicated that with the traditional curriculum students perceived a balance between learning CT and science concepts. In contrast with the UMC curriculum, students thought that they learned more CT concepts than science concepts. Teacher interviews confirmed the findings from the SNA. Lessons learned, recommendations, and discussion about the integration of CT and science learning are provided.

Examining the Role of Curriculum in Supporting Literacy Demands in NGSS Instruction

Carrie D. Allen, University of North Texas
Rasha Elsayed, WestEd
Ryan Burke, WestEd

ABSTRACT

Curriculum materials are expected to play a critical role in shaping NGSS teaching and learning. We examined the role of a set of educative curricular materials in supporting teachers' uptake of NGSS and Framework-oriented teaching practices. With regard to teaching practices, we focused on how the materials supported teachers in addressing students' language demands and the modifications teachers made based on perceptions of student need. We drew on teacher observations, interviews, and instructional log data for 3 teachers in 2 school districts serving predominantly EL populations to analyze both teachers' perceptions of the materials and their use of the materials during instruction. Our findings point to the struggles facing teachers and students as they take on new standards via new curriculum materials and offers insights to the practical tensions that those who are supporting science

teacher learning and implementation need to attend to in order to promote access and equity in science education.

International Baccalaureate Biology Curriculum Analysis
Mohammed Estaiteyeh, Western University

ABSTRACT
This paper aims at analyzing the Biology curriculum of the International Baccalaureate Diploma Program (IB DP). The curriculum is analyzed at two levels: the programmatic curriculum and its actualization in the classroom. The programmatic curriculum is taken from the IB official documents, whereas the actualization is based on my personal experience as an IB teacher for nine years. The analysis includes the curriculum objectives, topics, approaches to teaching and learning, lab work, and assessment procedures. It is done using the framework of Eisner's progressivism curriculum ideology. This ideology entails two main aspects: the human experience (student's personal aspect) and the social reform (political aspect). The paper elaborates on the aspects of this curriculum ideology and the details of how and to what extent they are expressed in the IB Biology curriculum. It is noted that the features of this ideology are highly evident in the IB Biology curriculum, with a stronger emphasis on the human experience aspect and a moderate reflection of the social reform one. In addition, both the programmatic and actualized curricula show the same trends. The paper also presents related challenges, implications, and recommendations. Keywords: International Baccalaureate, Eisner's progressivism curriculum ideology, curriculum analysis, curriculum development, secondary school science

Structural Causal Modeling of Science and General Core Competencies in Korean 2015 Revised National Curriculum
Gyeong-Geon Lee, Seoul National University
Hun-Gi Hong, Seoul National University
Yu-Jung Kim, Seoul National University
Wonhyeong Jang, Seoul National University

ABSTRACT
Competency-based curriculum has become one of the leading discourses on the 21st century curriculum studies. In the case of Korea, the core competency was introduced into the 2015 Revised National Curriculum. The relationship between general core competence and subject matter competence is a major issue in the competency-based curriculum discourse. Usually the general core competency is set first, and then the subject matter competency is set. On the other hand, in the developmental order, it is presupposed that the core competency will be cultivated after the curriculum competence is cultivated through the curriculum. However, there has been little research on the relationship between general core competencies and subject matter competencies in terms of educational measurement. In this study, the competencies of Korean high school students were measured by using the questionnaires for science subject matter and general competencies. The correlation between each core competencies of high school students were investigated, and structural causal models were compared to examine causality between science and general competencies. The result of this study is expected to provide a rich implication for Korea's national curriculum as well as the international theoretical discourse of competency-based curriculum.

Strand 11: Cultural, Social, and Gender Issues

Partnerships and STEM Learning Experiences Across (In)formal Contexts

8:00 AM-9:30 AM, Salon H

Presider: Eli Tucker-Raymond, TERC

Factors that Impact the Development of STEM Programming at a Newly Emerging STEM School

Felicia DT Leammukda, St. Cloud State University
Gillian H. Roehrig, University of Minnesota

ABSTRACT

There is an urgent call to improve K-12 STEM education and a need to provide all students the opportunity to participate in STEM in order to broaden the population of students who pursue STEM careers. National reports recommended the creation of more inclusive STEM schools in areas of under-represented populations. In response, the number of self-identified STEM schools has increased across the US. However, the quality of these schools is unclear and the research base for understanding qualities of STEM schools is under-developed. Existing literature focuses on well-established inclusive STEM high schools. Little research exists on STEM middle schools and the process of STEM programming development. This study focuses on an emerging STEM middle school and understanding the factors that impact STEM programming development. Using the 14 Critical Components for Inclusive STEM High Schools put forth by Lynch and colleagues (2017) as a guide, we found key factors STEM programming development: (i) STEM-Focused Curriculum For All, (ii) Flexible and Autonomous Administration, and (iii) Well-Prepared STEM Teachers and Professionalized Teaching Staff. Authors recommend: 1) building a STEM school upon the foundation of a well-functioning school and 2) developing a set of STEM school criteria in all states.

Rightful Presence and Power: Examining Our Research-Practice and Youth-Adult Partnerships

Day W. Greenberg, University of Michigan
Angela Calabrese Barton, University of Michigan
Carmen Turner, The Boys and Girls Club of Lansing
Kaila Williams, The Boys and Girls Club of Lansing
Jaila Williams, The Boys and Girls Club of Lansing
Za'Mani Roper, The Boys and Girls Club of Lansing

ABSTRACT

An important challenge in participatory design-based research are the structurally entrenched power dynamics that shape university-community partnerships. In our efforts we have sought to be mindful of the ways in which these entrenched power dynamics take shape in local practice, and collectively disrupt them in justice-oriented ways. The process is complex and loaded with tensions that can be challenging to navigate, yet essential for enacting humanizing research in consequential ways. We have drawn upon a framework of rightful presence to guide us in navigating these tensions and to look at how we try to enact unconditionality and equitable sharing in our long-term research-practice partnership (Squire & Darling, 2013). We examine how a deliberate enactment of the idea of rightful presence informs our partnership engagement at a daily level. We also explore what this looks like and produces for the research and practice we construct together. We present findings from six years of critical participatory and critical ethnographic research conducted in a long-term, research-practice partnership (a STEM-focused afterschool program) at a community organization in the North Midwest.

Findings inform how university scholars can better see, acknowledge, and work with community partners in research and practice.

Teacher learning, identity and agency, and the enactment of informal science learning in formal classrooms

Jennifer Adams, University Of Calgary

ABSTRACT

The 2020 theme urges us to examine science learning in different contexts with an aim to bridge learning between school and out-of-school settings. This includes teacher learning since teachers are charged with creating relevant and equitable science learning opportunities for all students. Informal science institutions have a long-standing history of offering teacher learning opportunities through professional development and, more recently, through formal courses and teacher certification programs. The learning experiences often center on science context and pedagogy through use of the institution's resources. However, questions remain of what happens to this learning when teachers return to the classroom? What are policy and/or logistical constraints and how do teachers navigate these? Using a lens of teacher identity and agency this paper describes how teachers define and use informal science learning resources and approaches in their classroom. This allows us to think differently about the relationship between informal science learning and teacher practice; moving from teaching teachers to use resources towards thinking about affording teachers agency in adapting resources to meet students' needs thus creating more opportunities for equitable science learning, thus shaping agentic teaching identities.

Teacher Perceptions as key role in science education outcomes across all Places and Contexts

Takeshia Pierre, University of Florida
Julie C. Brown, University Of Florida

ABSTRACT

White teachers make up 91% of the US secondary science teaching force, suggesting that students of color are primarily taught science by white educators. Considering that teachers have professed deficit perceptions of the families and communities of students of color, we interrogated, through critical whiteness theory, perceptions about students' science success shared by 40 white science teachers. Prior to a course on culturally responsive science teaching, participants' perceptions were elicited in an assignment where they either explained factors contributing to their own science success or factors contributing to the science success of "students of color." These artifacts were analyzed qualitatively with three themes identified: Family: When Resources and Setbacks are One and the Same; School: Resources Matter, Even When They Don't; and Community: Cabrini-Green vs Mayberry. We noted numerous instances of white privilege, deficit thinking, and the view that white privilege is not racism. Race-visibility is imperative in science, as it influences teachers' perceived abilities of students, addresses underrepresentation of STEM professionals of color, and the notion that although race is socially constructed, this discipline collectively views race through a biological lens. We discuss findings and implications for the preparation of culturally responsive, socially just science teachers.

Strand 12: Educational Technology

Beyond the novelty effect – examining learning affordances of XR educational technologies

8:00 AM-9:30 AM, Salon G

Not all Novelty Effects are Created Equal: Differential Gains in Self-Efficacy and Online Behavior

Shane Tutwiler, University of Rhode Island
Jason Chen, William and Mary
Amy M. Kamarainen, Harvard Graduate School of Education
Shari J. Metcalf, Harvard University
Tina Grotzer, Harvard University
Christopher Dede, Harvard University

Leveraging the novelty of virtual reality to challenge students' initial ideas of cells

Meredith P. Thompson, MIT
Lucy Cho, MIT
Melat Anteneh, MIT
Cigdem Uz Bilgin, MIT

Developing Spatial Awareness in Novel Learning Environments

Cigdem Uz Bilgin, MIT
Melat Anteneh, MIT
Lucy Cho, MIT
Meredith P. Thompson, MIT

Good Learning Shouldn't Be Novel: Individual Level Impact of Collaborative Learning in Mobile Augmented Reality on Student Learning

Denise M. Bressler, University of Pennsylvania
Shane Tutwiler, University of Rhode Island

ABSTRACT

Extended reality (XR) technologies bring new dimensions of science to learners. While these technologies may have a high novelty factor, XR has great potential to expand learning for individual students through immersion in a topic, embodied learning, and spatial presence. Access to technology has historically been the challenge for educational settings, now that cost is decreasing (Castaneda, Cechony & Swanson, 2018) the challenge will be having quality experiences that are designed around clear learning objectives (Sulleman, 2018). Research is needed to identify realistic goals and fruitful design pathways to reach those goals. In this session, we will explore the affordances of three different types of XR tools – virtual reality (VR), multiuser virtual environments (MUVEs) and augmented reality (AR) games. Each of the examples explores a different affordance: learning about cells through a cross platform VR and tablet experience, developing spatial ability through a VR game, developing and practicing scientific skills through a MUVE, and developing scientific thinking skills through a collaborative AR platform game. During the session, we will examine how we can move beyond the effect of novelty of these technologies towards a discussion of how these tools can be leveraged for deeper scientific learning and thinking.

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

Teaching of NOS

8:00 AM-9:30 AM, Portland

Presider: Jennifer C. Parrish, University of Northern Colorado

Understanding Teachers' Use of a Tool for Selecting Nature of Science Trade Books

Jeanne Brunner, University of Massachusetts Amherst
Christine McGrail, University of Massachusetts Amherst

ABSTRACT

Elementary teachers often use trade books to support science instruction, and their use has been shown to be effective for teaching nature of science (NOS). However, most trade books do not include explicit references to NOS, although they do provide the potential to address NOS. We report here on the Nature of Science Trade Book Selection Tool, which supports teachers in identifying segments of text in trade books that relates to NOS concepts. We present initial data describing (a) which segments of trade books elementary teachers identify as relating to NOS using the Tool, and (b) teachers' perceptions of the Tool's ease of use and the likelihood that they would use it in their own practice. We argue for the use of the Tool as one way teachers can identify NOS connections in their current curriculum materials and provide an outline of future research using the Tool.

Improving Students' Perceptions of NOS: An Experimental Study

Aysegul Cilekrenkli, Bogazici University
Ebru Kaya, Bogazici University

ABSTRACT

Erduran and Dagher's (2014) reconceptualization of Irzik and Nola's (2011) family resemblance approach is a relatively new approach in teaching nature of science (NOS). This framework was later called "Reconceptualized Family Resemblance Approach to Nature of Science (RFN)" by Authors (2016). This study is a part of a funded research study which investigates the effects of systematically integrating RFN into 5thscience content with a quasi-experimental design. This paper focusses on the changes in students' perceptions of NOS. During the intervention, RFN based instruction or regular practice was implemented in experimental and control groups, respectively. In order to compare the changes in the students' perceptions of NOS, semi-structured interviews were conducted with 3 students from each group before and after the intervention. Interviewees were selected based on their varying levels of initial NOS understanding which was assessed with RFN Student Questionnaire during the prescreening process. After transcription, thematic analysis was used to analyze the interview data. Comparison of the codes from the two groups indicate that a targeted, holistic approach can improve students' perceptions of NOS. Overall, the study has implications for the integration of a holistic account of NOS to 5thgrade science content.

Promoting 4th Graders' NOS and Environmental Views Through Bridging Formal and Informal Place-based SSI Learning

Ben C. Herman, University Of Missouri
Sarah V. Poor, University of Missouri
Robert T. Oertli, University of Missouri
Kristen Schulte, Missouri River Relief

Blake Romaker, University of Missouri

ABSTRACT
Promoting functional scientific literacy focused on the products and process of science (e.g., NOS) and sociocultural considerations facilitates effective SSI engagement. This type of functional scientific literacy could be fostered through place-based instructional approaches that “bridge the gap” between formal and informal science education contexts. This triangulated mixed-methods study investigates how a month long place-based education program titled Missouri River All Stars (MRAS) focused on local Missouri River SSI bridged the gap between informal and formal educational contexts and impacted the NOS views and pro-environmental perspectives of 54 fourth graders. The after-school MRAS program occurred in the students’ classroom and included a daylong Missouri River field trip. Salient themes included Missouri River human impacts, pallid sturgeon decline and recovery, and how scientists investigate those issues. Our results show that after the MRAS, the MRAS participating students expressed significantly more informed concepts about NOS themes, such as how scientists research Missouri River SSI. A comparison group of their classmates realized no such gains. However, no significant differences occurred in the pro-environmental perspectives of the MRAS participating students and their non-participating classmates. Pedagogical implications include how SSI engagement can be improved through leveraging place-based instruction that bridges formal and informal learning contexts.

What Changes to Students' Ideas About Science When History of Science Stories Become Everyday Homework?

Shiang-Yao Liu, National Taiwan Normal University, Taiwan
Cyong-Huei Chen, Jingxing Junior High School, Taipei, Taiwan
Shih-Yeh Chen, Dali Senior High School, Taichung, Taiwan

ABSTRACT
This research was aimed to design nontextbook reading materials regarding the history of science (HOS) that could improve students' understandings of nature of science (NOS). The multi-functional communication notebook was the target product for including historical vignettes regarding science and scientists, and prompt questions to elicit ideas about science. The design research methodology was adopted to study whether the product succeeds in affecting students' daily reading and their understandings of NOS. A total of 100 HOS essays were written by researchers, and reviewed and revised by experts for content accuracy. School teachers were interviewed to identify their strategies of using communication notebook for class management and gather ideas about how to design the page layouts. The product was field-tested with two classes of grade 8 students in a pilot study. Results indicated that students' understandings of NOS improved significantly after using the product for one semester. A larger scale study was then conducted with 18 classes from four different schools, involving grade 7 and 8 students. Students' epistemic beliefs about science and individual interest in science and reading were measured to evaluate what characteristics of this design product influence students' ideas about science.

Concurrent Session 8
10:00 AM-11:30 AM

Awards Committee

Admin Symposium-Diverse Scholarly Trajectories in Science Education: Charting Pathways for Science Education Research

10:00 AM-11:30 AM, Eugene

Diverse Scholarly Trajectories in Science Education: Charting Pathways for Science Education Research

Noemi Waight, University at Buffalo

ABSTRACT

The purpose of this proposal is to organize a research panel session that will highlight the work and contributions of the (a) Distinguished Contributions to Research Award [DCRA] (b) Early Career Research Award [ECRA] and (c) Outstanding Dissertation Research Award [ODRA]. The goal of this session is to celebrate the accomplishments of the awardees and provide a platform for a more extended discussion of the awardees' scholarly contributions. Essentially, the awardees will have a platform to provide a brief synopsis of their work and simultaneously engage with the theme of NARST 2020: School, Community, Citizenship: Science Education Across Places and Contexts. The goal here is for awardees to organize their presentation in a way that shares their work but also suggests two or three research directions that are aligned with their work and situated in the theme of the conference. For example, for the DCRA awardee(s) we would invite them to reflect on their work and the contributions of this work to the field and then propose one or two questions that are worth contemplation (hopefully that connect with the theme). For the ECRA and ODRA awardee(s) their summary would address why they elected to pursue this line of work, and how future work could be situated within the conference theme. Here they could identify one or two questions that could inform their future work. The panel session will be organized for presentations from the panelists and a brief Q/A segment. The board liaison will moderate the session. The panel proposed time frame is 1:30 minutes.

Indigenous Knowledge RIG

Admin Symposium-School, Community, Citizenship: Indigenizing Science Education across Places and Contexts

10:00 AM-11:30 AM, Salon I

Developing Indigenous students' STEM identities through a phenomenon-based approach: integrating a STREAM curriculum in the elementary classroom

Julie Robinson, University of North Dakota
Joshua Hunter, University of North Dakota
Bonni Gourneau, University of North Dakota
Anna Bahnson, United Tribes Technical College

ABSTRACT

In the STEM classroom, science content and engineering design tasks often are *acultural*, without being situated within community contexts, regions, or epistemologies (Bang & Medin, 2010), thus distancing students from a STEM identity that meaningfully reflects their culture and ways of knowing. This project, still in development, aims to explore how a phenomenon-based approach to STREAM (science,

technology, recreation, engineering, arts, and math), when situated geographically and culturally within distinct indigenous contexts, impacts students' perceptions and identities within STEM. This collaboration between the University of North Dakota, Turtle Mountain Community College, and the United Tribes Technical College will provide elementary students, representing several indigenous cultures across North Dakota, with an interdisciplinary curriculum connected to their local watershed, language, practices, and traditions. Building from the *River of Dreams* program, students, local Native artists, and teachers will work together to design and release boats into the river; use technological tools to track their boats; learn about the watershed through art, storytelling, writing, and language; and design solutions to problems within the watershed. We are interested in beginning a conversation around science education research and collaborations across cultural contexts. Important to consider is how research methodologies can likewise be culturally situated, participatory, and reflective of diverse perspectives and goals.

Indigenizing High School Science Curriculum: A Case of Indigenous Local School Board in Nepal
Mahesh Tharu Chaudhary, Shree Jagadamba Higher Secondary School
Dinesh Gautam, Shree Jagadamba Higher Secondary School
Bhaskar Upadhyay, University of Minnesota

ABSTRACT
The goal of this presentation is to share the challenges and politics surrounding the nature and the process of indigenizing high school science curriculum for grades nine and ten. In the context of Nepali education system grades nine and ten work as gatekeepers for students because the academic success in these grades determine their future academic and professional carriers. Many indigenous Tharu students are disfranchised from pursuing a science degree and career because science curriculum used to be developed without much regard to these students and their communities. Since the local schools are now given more autonomy to develop locally situated science curriculum, schools are taking this advantage. In this presentation we share six-month long process in indigenizing high school science curriculum that took place in a local school board in Nepal. We share the experiences of three members of the curriculum development committee highlighting challenges, compromises, and the politics. We specifically focus on the intersections and importance of how science content, Tharu community, and power influence the extent and nature of indigenizing science curriculum for the Tharu community. All three presenters are members of the curriculum committee which is working on indigenizing science curriculum.

Equity and Ethics Committee
Administrative Session
Jhumki Basu Poster Symposium
10:00 AM-11:30 AM, Hawthorne/Belmont/Laurelhurst
Organizers:
Gillian U. Bayne, Lehman College Of CUNY
Stephanie Eldridge, University of Georgia
Althea Hoard, Teachers College of Columbia University
Tara M. Nkrumah, Arizona State University
James M. Nyachwaya, North Dakota State University
Presider: Catherine Quinlan, Howard University

The Equity and Ethics Committee invites you to attend this thought-provoking and compelling interactive poster session with the 2018 and 2019 Basu Scholar awardees. These emerging scholars bring diverse educational perspectives and reflect a range of research interests in scholarship addressing equity and justice in science education. During this symposium, the Basu Scholars will present ideas and research focused on examining, shaping, improving and expanding science education across places and contexts.

White Teachers and Diverse STEM Students' Learning Progressions Towards or Away From Culturally Relevant STEM Education
Amelia A. Brown, University of Tennessee, Knoxville

ABSTRACT
The United States reports significant under-representations of people identifying as Black and Hispanic in STEM education and careers. Resultantly, research abounds on the achievement, participation, and motivation gaps that exist between diverse populations in STEM education and careers, and the important role of K-12 STEM teachers in providing equitable STEM education. An additional related factor is the predominantly White STEM teaching force. The documented participation gaps in STEM education and careers combined with overrepresentation of White STEM teachers naturally raises questions and concerns regarding the abilities of White STEM teachers to equitably teach and motivate diverse students. Culturally relevant STEM teaching can help bridge the racial and cultural divide between teacher and students, but often White STEM teachers struggle with culturally relevant pedagogy. This study focuses on the learning pathways of STEM teachers towards or away from enacting culturally relevant STEM teaching in their classrooms. Understanding the learning pathways both towards and away from cultural relevance helps identify missed opportunities in the unique and varied contexts that shape the teaching trajectories of STEM teachers. Capitalizing on these missed opportunities could have the impact of an increasingly equitable STEM teaching force better prepared to motivate all students towards STEM higher education and careers.

"Judgment Free" Space in Supporting African American Girls' Identity in STEM
Faith Freeman, Guilford County Schools/University of North Carolina at Greensboro

ABSTRACT
The disparity of African American girls following a STEM trajectory as compared to their White counterparts has not decreased much over the past years. Although the reason why this underrepresentation of African American females in STEM is unclear, evidence has shown that there is a specific relationship between gender and race as to why African American females do not pursue STEM majors. Therefore, it is imperative to create spaces where African American girls can engage in STEM practices, while collaboration amongst one another is fostered. This study explores the ways in which a Science, Technology, Engineering, and Mathematics (STEM) enrichment program that is free (as far as possible) of microaggressions and social structural constraints could influence African American girls to become innovators and to identify themselves as scientists or engineers.

Identities in Crisis?: Understanding the Identity Work of Elementary Students of Color
Terrance Burgess, Syracuse University

ABSTRACT
This project is part of study aiming to understand the identity work of elementary students of color at a time in which the Next Generation Science Standards are taking root within their school's science

program. While the Standards were developed with promoting diversity and equitable science learning opportunities at its core, the findings of this work suggest more intentional work must be done to bring students of color into the fold. A total of fourteen fifth-grade students and their classroom teacher participated in this qualitative study with data collection measures consisting of videoed classroom lessons, classroom observations, document analysis of student work, and semi-structured interviews. Utilizing Varelas, Martin, and Kane's (2012) *Content Learning and Identity Construction* (CLIC) framework, the findings of this project suggest while students of color espoused multiple layered and complex identities (racial, disciplinary, and academic) within their classroom, their science identities were largely influenced by their notions of being a "good student." This academic identity influenced their access to the classroom space, as students are always expected to abide by classroom rules and manifested in their science notebook entries as they communicated their scientific understandings. Although aware of their racial identities, students adopted colorblind rhetoric when describing scientists despite acknowledging the lack of diversity in expressed racial identities of scientists in media and curriculum materials, indicating the need for more culturally relevant curriculum materials in elementary science classrooms.

Supporting Student Interest Development and Transformative Learning in Geoscience: The Testing of a Socio-Cognitive Pedagogical Model
Shondricka Burrell, Duquesne University

ABSTRACT
Students in poor and historically marginalized communities are more likely to lack access to curricula that combines relevant science content and investigative practices—components the National Research Council (2012) has identified as necessary for effective learning. This lack of curricular access is also problematic because it: undermines student interest, and perceived value and relevance of science; and hinders student conversion of science content into actionable knowledge. To address this educational opportunity gap, I developed and tested the efficacy of a pedagogical model informed by the socio-cognitive constructs of interest, self-efficacy, and transformative learning (perceived value, relevance, and application of science). Using data collected from four U.S.-based high schools, my objectives were to: (1) examine the data for evidence of shifts in science perception; (2) investigate the relationship of these constructs and student knowledge; and (3) test the effectiveness of the model in knowledge acquisition and retention. Iterative content analysis of student writing shows evidence of transformative learning. Multivariate analyses indicate statistically significant and meaningful positive shifts in knowledge, and perceived value, relevance and application of science. Lastly, results from structural equation modeling, model fit analysis, and path analyses, provide evidence that the pedagogical model is theoretically sound, viable, and trustworthy.

Do students gain scientific inquiry knowledge and practices by participating in a school garden inquiry unit
Carmen Angelica Carrion

ABSTRACT
Since the turn of the century gardens have been spaces for learning to take place. Gardens allow for a variety of disciplines lobe explored from horticulture to art. In the mid nineteen nineties a school garden movement began to grow, in the United States and by the early two thousands several states had implemented a school garden policy. The majority of school gardens focus on academic outcomes (e.g. science, math, or language arts) or health outcomes (e.g. nutrition, well- being, and self esteem).

Currently, there is limited information about how school gardens can be a place for scientific inquiry and practices to develop in students. Furthermore, more in-depth mixed-method research on school gardens and how school gardens can produce learning opportunities for scientific practices to develop need to be conducted. Future research should take a new direction. The scientific practices created by Next Generation Science Standards (NGSS) (2013) need to be explored further in relation to how exposure to a school garden can affect these practices and knowledge about inquiry learning (Callahan, 2012; Chi, Dorph & Reisman, 2016; Kisiel & Anderson, 2010). Through this dissertation, school gardens can be viewed as an extension of the traditional classroom. School gardens have the potential lo foster learners ' abilities to construct real-life associations with science content due to engagement, free exploration and scientific investigation. The goal of interdisciplinary research on scientific inquiry and scientific practices in school gardens is to find new avenues to help develop better scientific literacy universally across learners. This research work will create curriculum and assessment tools for school gardens lo investigate if and how scientific inquiry and scientific practices are occurring in these school garden settings.

Does Systematic Professional Development(PD) for Science Teachers of English Language Learners(ELLs) Meet Their Professional Needs and What is the Relationship Between Perceptions of PD and Self-Efficacy to Teach Science to ELLs?

Lillian Hau-Degand, Illinois Institute of Technology

ABSTRACT

Professional learning is essential for science teacher preparation to teach science and part of a national movement to prepare students, including English Language Learners, (ELLs) for the demands of a 21st century workforce. The purpose of this research was to explore a) what science teachers feel they need in professional development to meet the needs of teaching science to ELL students; b) if science teachers demonstrate best practices learned in PD when teaching ELLs; and c) if there is a relationship between perceptions of professional development and self-efficacy in teaching science to ELLs. Little is known about what science teachers need in their professional learning to effectively teach science to ELLs. Four data collection phases were used to ascertain teacher needs, preparedness, self-efficacy, and their ability to teach science to ELLs. The data were collected through two surveys, interviews, classroom observations, and case studies. The data were analyzed using a correlation analysis of the two surveys or coding interviews and observations into themes in relation to each research question. The findings in this study. Findings in this study revealed no correlation between perceptions of PD and self-efficacy when teaching science to ELLs. Professional learning needs for science teachers with 50%> ELLs included sustained PD in science and ESOL, language development strategies, technology and material resources, and support for teaching from additional personnel and administrators. Most teachers were utilizing best practices when teaching science to ELLs but to varying degrees and had high scores in self-efficacy though they believed they were not prepared to meet the needs of ELL's. Consequently, discovering science teachers' needs by engaging them, as stakeholders in a process to include their needs, will create a structure that can design PD which can promote science among ELLs and today's cultural and diverse classrooms.

Students know the language boundaries in Science: Challenges and Opportunities of Translanguaging in engineering learning

Greses Anabell Perez, Stanford University

ABSTRACT

In recent years, the demographic shifts in the United States have increased the number of multilingual learners in schools. These schools are now teaching engineering as result of the new frameworks for elementary and secondary science education. The inclusion of engineering into science education poses new challenges and opportunities for culturally and linguistically diverse. Students are now expected to engage in the language-intensive practices of specialized fields while developing basic literacy in English. However, research on multilinguals often assumes a homogenous experience in learning settings while omitting the complexity within these communities. Contemporary research has yet to explore questions about the role of language in science and engineering. Drawing on theories of sociocultural science education and translanguaging, this study explores the ways students negotiate language in science and engineering and the influences of language boundaries in the classroom. Through event mapping of participants' video data, this paper seeks to understand language negotiation in three different linguistic contexts during an engineering program at a private university in Northern California. The results of this study suggest that participants negotiated linguistic resources depending on the linguistic setting and receiver of the message.

Active learning in large STEM classes: Perceptions from Undergraduate and Graduate Students

Ngawang Y. Gonsar, Gustavus Adolphus College
Lorelai Patrick, University of Minnesota
Sehoya Cotner, Gustavus Adolphus College

ABSTRACT

Despite the evidence in support of active learning, reliance on lecturing remains pervasive in STEM higher education. Though many instructors realize the value, they resist implementing active learning techniques in their courses. When queried about their reluctance to implement active learning, faculty often cite an array of barriers - most notably, a perceived lack of student buy-in and class sizes that are prohibitively large for active learning practices. On the other hand, few studies have explored student perceptions of active or examined active learning practices in smaller classes such as those in graduate-level courses. Through survey-based research, we explored student perceptions of 23 active learning teaching strategies in both graduate and undergraduate classrooms across the three STEM colleges at a large mid-western university. We found that traditional lecturing was the most experienced mode of teaching in both graduate and undergraduate classes despite a 128% difference in mean class size reported between graduate and undergraduate courses. Both graduate and undergraduate students overwhelmingly desired more time devoted to active learning than was experienced in their large STEM classes. Both these populations also wanted less lecturing as the primary mode of instruction. Our study also demonstrated that no single active learning practice was universally preferred or unwanted. These findings suggest that instructors should implement a variety of active learning practices in their classrooms, for graduate and undergraduate students alike. Finally, our results have implications for faculty professional-development programs at all levels of post-secondary instruction.

Exploring preservice teachers' developing understandings of equitable pedagogies for engaging elementary students in science practices

María González-Howard, The University of Texas at Austin
Tia Madkins, The University of Texas at Austin

Tatiane Russo-Tait, The University of Texas at Austin
Maximilan Sherard, The University of Texas at Austin

ABSTRACT
Recent reform standards, like the NGSS, contend that students ought to engage in science practices to develop and refine their own understandings of the natural world. Science practices capture and represent wide-ranging ways by which diverse communities make sense of scientific phenomena. Thus, learning environments grounded in the science-as-practice approach hold promise for addressing inequities in science education, especially for students from historically marginalized groups. However, realizing the vision set forth by the NGSS depends in part on developing new teachers who have undergone training that forefronts what it means to teach and support students in equitable ways in doing science through science practices. This study, contextualized in an Elementary Science Methods class, highlights an effort to address this needed teacher training. Specifically, we examined preservice teachers' developing understandings of equitable pedagogies for supporting and engaging elementary students in science practices. Using a multiple-case study methodology, we explored variation in how preservice teachers discussed and problematized science instruction for elementary students, especially as it related to students meaningfully engaging in sense making activity. Furthermore, we examined how this variation manifested in the ways preservice teachers designed, carried out, and reflected upon science lessons meant to engage students in science practices.

Approaches to Learning Biology of Women of Color: The Intersectionality of Gender, Race, and Science Identity

Angela N. Google, Middle Tennessee State University
Anna S. Grinath, Idaho State University
Grant E. Gardner, Middle Tennessee State University

ABSTRACT
Despite steady growth in national diversity, women of color continue to struggle in accessing higher education and persisting to graduation in STEM fields. Recent shifts in the national narrative from a deficit-based approach towards a strength-based approach to understanding women of color in academic settings, illuminate cultural and social factors that may contribute to positive student outcomes. Science education literature commonly associate deep, versatile learning approaches with high academic achievement, requiring students to develop life skills such as complex problem-solving, innovation, and adaptability to the rapidly changing knowledge base. However, the adoption of deep approaches to learning are strongly influenced by overlapping factors within social and academic environments. Women of color rest at the intersection of such personal and social factors; factors that were historically unexamined in women of STEM scholarship. Through the lens of intersectionality, this study examines the personal/cognitive factors of race/ethnicity, gender, and science identity for women of color. In addition, this study examines how this mutually constructed identity recognized by each woman of color interacts with the social factors of how each woman of color is recognized within the undergraduate biology community to better understand how this interaction account for her approaches to learning biology.

Urban Science Teacher Education Across Contexts: An Examination of Teacher Learning through the Lenses of Identity and Agency
Stefanie LuVenia Marshall, University of Minnesota

ABSTRACT
Teachers who remain committed to teaching in high-need schools identify not just as teachers, but as teachers devoted to working with underserved students. Teacher education programs have an important role to play in the development of teachers who espouse social justice in their teaching. But, the transition from university preparation to in-service teaching is difficult, particularly for teachers who have a mission to interrupt patterns of injustice. This study explored the complexities of novice science teachers negotiating the social, pedagogical, and political divide between an urban science teacher education program focused on social justice and the contexts of urban schools. Guided by the frameworks of identity and agency, I analyzed the experiences of one cohort of Science Educators for Urban Schools (SEUS) for two academic years: pre-service and the first year of teaching. Findings highlighted how novice teachers encountered dictated structures for teaching and learning forced novice teachers to confront their core values and beliefs in their first year of teaching, particularly as teachers for social justice. These findings highlight the political and personal dimensions of teaching science for social justice and indicate urban science teacher effectiveness and retention is dependent how successfully novice teachers negotiated organizational contexts.

Revealing the Queer-spectrum in STEM: Undergraduate Student Responses to Diverse Gender Identity and Sexual Orientation Demographics Questions
A.M. Aramati Casper
Katherine Ray King
Rebecca A. Atadero
Linda C. Fuselier

ABSTRACT
Queer individuals face notable heterosexist and gender-normative expectations in STEM, leading to lower persistence. However, research on the experiences of queer-spectrum individuals is limited by current demographic practices. We developed queer-inclusive demographics questions and administrated them as part of a larger study in undergraduate engineering and computer science classes. We ask: how do responses compare to nation-wide queer demographics, 3-7% for both sexual orientation and gender, and how common are heterosexist or binary-enforcing responses? In a data subset (n=314), 14% of students reported a queer sexual orientation and 1.3% of students reported a queer gender. Few students used the open-response box for gender binary-enforcing (1.3%) or heterosexist (0.3%) commentary (e.g. only two genders exist). Our high rate of queer sexual orientation responses may be explained by our broad definition of queer or differing population demographics for young adults. The low rate of queer gender identity may be due to under-representation, lack of self-reporting, or survey structure. These data will inform analysis of student experiences in our larger study. Additional work developing a research-based queered demographics instrument is needed for larger-scale changes in demographics practices, which will help others identify and address barriers that queer individuals face in STEM fields.

Othermothering in Science Education: When Leading Transcends Walls
Stefanie LuVenia Marshall, University of Minnesota

ABSTRACT
This study examines the role of a Black principal who drew from various community members within her network (e.g. the school nurse, parents, the school paraprofessional) to meet the needs of both her students and community. There is a need to both prepare principals to make informed science decisions for our most vulnerable populations as well as learn from school leaders whose roles transcend the wall of the school and serve as othermothers. Othermothering is defined as the women who assist blood mothers by "sharing mothering responsibilities (Collins, 1997, p. 5)". African-American educators have been found to have learned from women who nurtured them and then transferred these understandings to children in their care as they seek to counter the status quo as political figures. This study examines the ways in which an African-American principal used her social capital to maximize her impact as an othermother-- leveraging the needs of her community

Urban Students' perspectives on Advanced Placement Enrollment
Justina Ogodo, Baylor University School *of Education*

ABSTRACT
Despite the expansion of the advanced placement program to include all students regardless of their demography, location, or socioeconomic status, minority students are still underrepresented in the program. This study surveyed 256 urban students who were enrolled in advanced placement (AP) courses to examine their motivation to enroll in the program. The findings indicated that two major predictors: a) students' intrapersonal persuasion and b) teacher knowledge base, influenced their decisions. This inquiry highlights students' use of human agency to make decisions that may inform stakeholders on how to better recruit, prepare, and retain them in the AP program.

Indonesian Preservice Biology Teachers' and Biology Education Professors' Views on Evolution: Religious, Socio-cultural, and Dilemma of Teaching and Learning Evolution
Arif Rachmatullah, North Carolina State University

ABSTRACT
Indonesia is known as a religious country that values local wisdom and customs. Characteristics of Indonesian people may provide novel insight and distinguished views on evolution. However, studies that explore how Indonesians view the theory of biological evolution are limited. Thus, the objective of this study was to explore views of undergraduate students and their professors majoring in biology education on the theory of evolution. The multiple-case approach was used as the method of this study. Three preservice teachers and three Indonesian biology education professors were interviewed. Results revealed that participants embraced creationism without accepting human evolution theory. One intriguing result was that most Indonesian professors tended not to agree that there was a conflict between evolution and religion. By seeking harmonization between evolution and religion, this study also categorized different approaches of evolution acceptance and its relation to religion. Additionally, participants connected their views to the current state of science curriculum that embraced the idea of harmonization between science and religion. How participants negotiate the dilemma between evolution and personal/cultural value is also discussed.

Joys and Traumas of Black Female Science Teachers, A Phenomenological Study

Alexis Riley, Teachers College, Columbia University

ABSTRACT

This phenomenological research study examines the experiences of three Black female science teachers that have both experienced and participated in the triumphs and failings of today's educational system while teaching Black and Brown students. The following themes capture the essence of their experience, (a) Sankofa: K-12 experience influences their own K-12 teaching due to positionality, (b) Hidden Curriculum, (c) Curriculum Violence, and (d) Race in Science Education

Minority STEM Undergraduates: A Comprehensive Model for STEM Identity and Self-Efficacy

Kelly Marie Shepard, Illinois Institute of Technology
Ivan Mutis

ABSTRACT

The examination of the experiences of undergraduate minority students who pursued degrees in science, technology, engineering, and mathematics (STEM) revealed correlations between improved self-efficacy/identity and students' increased persistence and integration into the scientific community. The reported mechanisms to improve the self-efficacy and identity of minority undergraduates were: 1) mentorship by STEM professors and/or professionals, 2) informational sessions that familiarized students with research methodologies, 3) original research guided by student-generated questions, 4) opportunities for students to present the research they conducted, 5) student-centered events that built community and offered peer-support, and 6) financial assistance. Taken together, the aforementioned elements have the capacity to increase the graduation rates for minority students in STEM majors. To address the motivators and enablers that support graduation, the study focused on an intervention that promoted a uniquely comprehensive model designed to reveal a spectrum of improvements over time in STEM students' identity and self-efficacy. The findings of the intervention are presented and include implications for institutions of higher learning pertinent to the self-efficacy and identity of minority undergraduates in STEM.

Power at play: The social, political, and cultural mechanisms of digital game-based learning in science

Ora D. Tanner, University of South Florida

ABSTRACT

This study examined the social, political, and cultural considerations employed during the design process of a digital science game developed as part of a Mathematics and Science Partnership research grant. Methodological reflexivity was used to situate myself within the research process and reflect on my assumptions, attitudes, and biases at every stage, examining how these may or may not have influenced the design, development, and implementation of a science game for middle grades students. Results show there were points of contention between the cultural norms of cognitive science and psychology as well as disciplinary mindsets within my instructional technology doctoral program and my own personal values, practices, and intersectionality as a Black female game designer. Design considerations that framed the game will be outlined and challenges encountered during the design process due to opposing perspectives from instructional technology frameworks and my own critical worldview will be highlighted. Critical theory was used to identify an explanation of the causal powers that shaped the final form of the game. Implications of critical game design in science for minoritized students, teachers, researchers, game designers, instructional technologists, policymakers, and other stakeholders will be discussed.

Girls prefer Biology, Boys Physics: Gender Differences in School Science Content Interest
Radu Bogdan Toma, Universidad de Burgos
Jesus Ángel Meneses Villagrá

ABSTRACT
Statistics on enrolment in Science, Technology, Engineering and Mathematics (STEM) show a large under-representation of women in most of these disciplines. This study analyses the preferences of elementary education girls and boys (n = 733) for learning physics and biology school science content using a person-centered analysis method based on clustering techniques (K-Means). The results reveal the existence of a sexually biased attitudinal profile, characterized by a high preference for the content of the biological sciences and a low preference for learning physics among girls, and opposite results in the case of boys. In addition, compared to boys, girls were majority in the attitudinal profiles characterized by a low overall interest in studying science content and minority in the profiles characterized by a high interest in both disciplines. These results suggest that the differential interest towards science disciplines between girls and boys emerge from elementary stages of the educational system, which could lead to the subsequent gender segregation existing in STEM disciplines. Educational implications of these findings are discussed.

Becoming a Teacher: Reflective Practice As a Way Of Exploring Secondary Science Teacher Beliefs And Practices
Preethi Titu, University of Minnesota

ABSTRACT
Teachers' beliefs about science teaching are established and nurtured through their own experiences as learners. While teacher beliefs have a significant impact on their classroom practices and provide a strong basis for their classroom actions, teachers’ sense of identity has been shown to play a key role in their understanding of their own actions. This qualitative study followed three beginning secondary science teachers working in high need schools throughout a three-year induction period and explored their practice, thereby enabling them to reflect on those practices that help build an understanding of their continuous process of science teaching development while identifying who they are as a teacher. The study used a framework of evolving teacher identity modified from Beauchamp and Thomas (2006) to explore the teachers’ identity development in terms of their classroom roles and responsibilities, the ways they think of and describe themselves as professionals, and their beliefs and practices about their classroom teaching and student learning. Data were collected from multiple sources, including classroom observations, teacher interviews, and reflective journals. The findings provide insight into how beginning teachers perceived their identities based on the three themes: (a) role as a teacher; (b) teaching practice, and (c) enhancing student learning.

Examining Elementary Students’ Images of Engineers and Interests in Engineering Careers
Ezgi Yesilyurt, University of Nevada, Las Vegas

ABSTRACT
This study investigated the effect of an engineering design experience on elementary students’ images of engineers and their interests in engineering careers. Participants were six upper elementary students from different schools in the southwestern United States. The students participated in a STEM program in which they were exposed to an explicit-reflective engineering instruction and engaged in the engineering design process to construct soda can crushers. We administered an open-ended

questionnaire asking students if they have ever thought about becoming an engineer, what engineering is and what engineers do as well as to draw an engineer at work and explain what the engineer is doing at the beginning and end of the program. Additionally, we conducted semi-structured interviews during which students were asked to elaborate on their responses and drawings. The findings indicated that most drew themselves as engineers and expressed their interests in becoming an engineer to solve human problems at the end of the program. Also, the intervention seemed to have an impact on students' views of engineering and engineers' work. The study suggested that engineering design experiences supported with explicit-reflective instruction could help elementary students improve their views of engineering and overcome their stereotypical images of engineers.

Re-novicing to teach science: the case of an experienced elementary teacher

Lu Wang, University of Georgia
Hui Tang

ABSTRACT
Teach a new subject is challenging, even for experienced teachers. However, the phenomenon of assigning teachers to teach new courses are prevalent in elementary schools, especially in high-poverty schools. Providing additional supports is essential for these teachers' professional development who are assigned to teach new subjects. The objective of this case study is to understand how an experienced elementary teacher who has not taught science for the last ten years, learned to teach science with the support of a science teacher educator. The science teacher educator designed inquiry based activities, demonstrated to the teacher in professional learning meetings, assisted her science instruction and debriefed with her after each class. Qualitative analysis of observation and interview data showed that (1) The teacher created a co-learning environment with the students; (2) The teacher incorporated math and ELA (which she taught over 10 years) knowledge continuously in her science teaching. (3) Teacher's thinking aloud facilitated students learning.

Strand 1: Science Learning, Understanding and Conceptual Change

Student Learning

10:00 AM-11:30 AM, Salmon

Presider: Jonathan Shemwell, University of Alabama

Arts-Integrated Impact on Earth Science Misconceptions: Exploring instructional order effects in elementary school science

Joseph T. Wong, University of California, Irvine
Sage Andersen, University Of California - Irvine
Michael Corrigan, MDED Inc
Doug Grove, MDED Inc.
Brad Hughes, University Of California, Irvine

ABSTRACT
The elementary years are a pivotal time for student science learning, as they are introduced to foundational and crosscutting concepts critical for future science achievement. However, this is also the time when students may begin to develop or solidify previously held science misconceptions. Pedagogical practices that facilitate conceptual change have been shown to directly address misconceptions. In a previous study, we found that leading with Visual and Performing Arts (VAPA) methods before Inquiry on Life Science standards lead to greater science knowledge gains in elementary

grades, specifically those challenged by misconception issues (Authors, 2019) Therefore, to investigate if complementing Inquiry-Based science instruction with VAPA-based science instruction can help create a more equitable educational approach to today's more diverse population of students, this research sought to explore: (1) does leading with visual and performing arts (VAPA) lessons before inquiry lessons increase student science knowledge while reversing common Earth Science misconceptions and 2) how does implementation fidelity contribute to the effectiveness of VAPA first science teaching efforts pertaining to the reversal of misconceptions in Earth Science? Results indicate that both VAPA and Inquiry methods offer an alternative approach to educators for teaching in elementary science when specifically targeting conceptual change.

Examining Middle School Students' Knowledge and Beliefs of Earthquake and Tsunami

Douglas S. Lownsbery, Oregon State University
Lawrence B. Flick, Oregon State University

ABSTRACT

Recent state, national, and international reports have called for increased earthquake and tsunami education to increase knowledge of the causes and risks of these hazards and the preparedness measures to reduce risks and increase resilience. One recommended approach to meet this need is to integrate earthquake and tsunami education into instruction in science and other subject areas in the K-12 school system. However, there is also a need for a strong theoretical basis for what constitutes effective earthquake and tsunami education. Using the lens of conceptual change theory, this study examined students' science knowledge, preparedness knowledge, epistemic beliefs, and ontological beliefs of earthquake and tsunami using multiple data collection instruments that required multiple response modes including textual, graphical, and verbal responses. Student responses were analyzed through a process of both deductive and inductive content analysis. Several themes were identified in the responses that can inform the content and pedagogy of earthquake and tsunami education. Study results indicate that conceptual change theory is a valuable lens for examining students' knowledge and beliefs of earthquake and tsunami and has potential for examining students' knowledge and beliefs of other important socioscientific issues.

Learning Progression of Students' Reasoning about Life Cycles

Hayat Hokayem, Texas Christian University
Ihsan Ghazal, Modern Community School
Fady Maalouf, Modern Community School
Savannah Graham, Texas Christian University
Hui Jin, Educational Testing Service

ABSTRACT

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

incomplete metamorphosis, and the fourth recognizing the similarities and differences between life cycles at every stage. Most of the students remained at levels one and two even after instruction, and none of the student responses reached level four when comparing different life cycles. We discuss the implications of those results for curriculum and instruction.

Student Learning of Emergent Science Processes Using the PAIR-C Framework

Brandon VanBibber, University High School
Polly K Lai, Queensland University
Lu Ding
Josh Adams
Michelene Chi, Arizona State University

ABSTRACT
Studies exploring student understanding of science processes suggest that student explanations of how patterns are produced in nature are littered with misconceptions and resistant to change through traditional instruction. One common misconception displayed by students is the claim that diffusion and natural selection patterns are produced intentionally by agents, even though agents in these processes do not have control over the pattern they produce. We propose that student misconceptions arise because students incorrectly align information about emergent processes into a sequential schema, as characterized in the PAIR-C framework, and that teaching students the underlying characteristics of emergent processes using the PAIR-C framework will improve their understanding of emergent science concepts. This study implemented a quasi-experimental design, in which 20 students received content about Diffusion and Natural Selection embedded in the PAIR-C framework, and 17 students received "Business as Usual" content that was unassociated with the PAIR-C framework. Our study found that students who received PAIR-C content outperformed the students who received generic content on the concept of Diffusion but not the Osmosis (transfer), Natural Selection, or Speciation (transfer) content. This article presents an explanation of the PAIR-C framework, our instructional intervention, results, and directions for future research.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Disrupting Science Education Across Contexts: K-12 Learning, Teaching & Local Communities
10:00 AM-11:30 AM, Mt Hood

Immersive Science Learning using the Eco Challenge App

Michelle Williams, Michigan State University
Manju Lind, Williams Learning Solutions

Making Assessments Essential to Elicit Student Thinking: Emphasis on Crosscutting Concepts

Dante Cisterna, Educational Testing Service
Lei Lui, Educational Testing Service

Elementary Principals as Boundary Spanners: How One's Social Network Impacts Decision-Making for Science

Stefanie Marshall, University of Minnesota

Centering Critical Race Epistemology in the Learning to Teach of Science
Christina Restrepo Nazar, California State University, Los Angeles

ABSTRACT
Implementing reform efforts requires working across fields (e.g., K-12 education, teacher preparation, business, policy), which often work in silos and with different goals. The Framework for K-12 Science Education raises the challenge that science education needs to work as a system-- however this system is complex. The system is defined as, "institutions and mechanisms that shape and support science teaching and learning in the classroom. Thus the system includes organization and administration at state, district, and school levels as well as teacher education, certification requirements, curriculum and instructional resources, assessment policies and practices, and professional development programs (NCES, 2012, pg. 241)." A system approach is needed to enable the relationships and synergies between these silos, to impact science education and address the challenges that affect our nation's innovation and competitiveness. In this paper-set we attempt to bridge these silos by examining a selected set of initiatives that illustrate the role of cutting-edge learning technologies, assessment models, youth and equity-centered orientations toward science in elementary teacher preparation programs, and considering the complexities of systemic science needs.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Teacher Perspectives, Contexts, Networks, & Roles
10:00 AM-11:30 AM, Meadow Lark/Douglas Fir - 3rd floor
Presider: Xiaoxin Lyu, Teachers College Columbia University

Leveraging Networks to Achieve Change at Scale: Identifying Capacity for Science Professional Learning in Schools
Thomas "TJ" McKenna, Boston University
Todd Campbell, University of Connecticut

ABSTRACT
Educational reform ultimately relies on teachers drawing from local knowledge and implementing new practices in their classrooms. To achieve the ambitious vision being called for in current science educational reform documents, one promising indicator to leverage teachers' and leaders' collective knowledge to enact reform is through a careful examination of the nature and quality of the formal and informal social networks within and across schools. Social network theory is an important lens to when viewing educational reforms as they are implemented at the school level and have been found to play a meaningful role in the success or failure of school-wide reform efforts. The major findings of the current study suggest the need for schools to be explicitly structured in ways that encourage and support ongoing learning for science teachers. This study also suggests an approach that administrators could use to examine the structure of their schools' advice network(s) to better understand the potential for engaging in education reform efforts like highlighted in the Framework and the Next Generation Science Standards.

Rattlesnakes with Vision: Teacher Perspectives of Administrative Affordances and Constraints to District-Wide STEM
Michael Giamellaro, Oregon State University - Cascades
Debbie Siegel, Institute for Learning Innovation

Benjamin Ewing, Oregon State University

ABSTRACT
School change is difficult and is both leveraged and hindered by interactive influences within complex systems of social practice. A qualitative case study approach was used to analyze educator perspectives of affordances and constraints to implementing project-based, STEM focused curriculum across all grades and classes of a rural school district. The case was informed by educator journals and interviews over the first 1.5 years of the initiative. Administrative and district factors were identified by practitioners as having a crucial role in advancing the implementation of STEM across the district, but even more so, hindering STEM implementation. Perceptions of misused power, misplaced resources, and variable vison and guidance, as expressed by participants, are contrasted with big picture visioning and resourcing to show a complex picture of a school district undergoing a STEM reform process.

Caregiver-Child Interactions during a Family Making Program: Our Role as Facilitators and Researchers
Jing Yang, Indiana University
Amber M. Simpson, Binghamton University
Adam V. Maltese, Indiana University
Euisuk Sung, Indiana University

ABSTRACT
Making as an educational practice provides rich science learning opportunities. Informed by literature on the crucial role of families in children's paths toward STEM careers, this project aimed at developing, implementing, and refining a program for integrating making practices into home environments of families in which caregivers and child act like co-makers. Utilizing video data from session one for three family dyads, we coded child, caregiver and facilitator verbal and non-verbal behaviors. From caregiver and children behaviors, we found caregiver-child interactions changes among four types, i.e., Parallel/Shared, Child-dominated, Parent-dominated and None. Time-window sequential analyses indicated family interaction was 1.3 times more likely to occur with the presence of a facilitator. The influence of facilitator's presence on dyad interaction changes can be either positive or negative. Though current data suggests the changes are not necessarily positive ones, we learned to avoid facilitator practice that leads to negative changes and further analysis should reveal practices that lead to more positive outcomes. Finally, we expect this project to be the first step to support under-resourced families to enhance their awareness of and affinity for STEM careers.

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

Formative Assessment tolls and practices

10:00 AM-11:30 AM, Salon E
Presider: Jonathon Grooms, George Washington University

Analytical Framework of Influences on Science Teachers' Formative Assessment (FA) Practices
Ira Caspari, University Of Massachusetts - Boston
Hannah Sevian, University Of Massachusetts Boston

ABSTRACT
In a time of increasing globalization, it is crucial that students are prepared to use their science knowledge to reason, solve problems, and practice socially responsible decision-making. Thus, teachers

need to develop assessment strategies that monitor and enhance these competencies. Research suggests that teachers can enact formative assessment (FA) in this way, however, they often focus on how students' answers compare to the canon as represented by the curriculum. When shifting toward FA enactment that is more responsive to student reasoning, teachers encounter various conceptual, pedagogical, cultural, and political dilemmas. Here, we present an analytical framework that can be used to analyze influences on the development of teacher FA practices and strategies teachers use to overcome dilemmas. Our development of this analytical framework is based on cultural-historical activity theory and is comprised of two stages. First, we present an initial analytical framework developed using activity theory to interpret and combine Windschitl's (2002) dilemma categories and the Authors' (2019) FA enactment model. Second, we present the refinement of this initial framework through a case study of two teacher cases. The impact of this novel analytical framework on research and practice is discussed.

Qualitative analysis to Elicit Features of Epistemic Knowledge When Middle School Students Engaged in Dialogical Argumentation

Getachew T Zegeye, Addis Ababa University
Jonathan Francis Osborne, Stanford Graduate School Of Education
Mesfin Tadesse Beshah, University of Addis Ababa

ABSTRACT

This paper attempted to identify the elicited feature of epistemic knowledge of science of middle school students in Ethiopia as a consequence of implementing dialogical argumentation as a pedagogy in physics instruction. The study draws on the styles of scientific reasoning frameworks to elicit feature of epistemic knowledge in science. Fifteen middle schools participated (N=6 as treatment group; N=9 as a control group). A total of 30 videos were recorded when discussing structured scaffolding activities; "Measuring Temperature" during pre-intervention and "Force and Motion" for post-intervention phases from students' argumentative group tasks. These videos of group tasks were translated, transcribed, and analysed in NVivo to identify the elicited features of epistemic knowledge of science. The study found nuances of epistemic differences between treatment and control group. The analysis of pre-intervention students' argumentation, from both groups, revealed that students mainly depends on their prior knowledge to justify their claim to knowledge. However, the post-intervention analysis revealed an epistemic shift by treatment group compared to control group. Moreover, the treatment group depicted explanatory coherence and seems to understand the role of justification to claim scientific knowledge. This result of this study attested that engaging students in argumentative group task enhanced their cognitive process to justify and evaluate scientific claims. In addition, to engage students in such discursive activity, enhanced their epistemic discourse.This paper attempted to identify the elicited feature of epistemic knowledge of science of middle school students in Ethiopia as a consequence of implementing dialogical argumentation as a pedagogy in physics instruction. The study draws on the styles of scientific reasoning frameworks to elicit feature of epistemic knowledge in science. Fifteen middle schools participated (N=6 as treatment group; N=9 as a control group). A total of 30 videos were recorded when discussing structured scaffolding activities; "Measuring Temperature" during pre-intervention and "Force and Motion" for post-intervention phases from students' argumentative group tasks. These videos of group tasks were translated, transcribed, and analysed in NVivo to identify the elicited features of epistemic knowledge of science. The study found nuances of epistemic differences between treatment and control group. The analysis of pre-intervention students' argumentation, from both groups, revealed that students mainly depends on their prior knowledge to justify their claim to knowledge. However, the post-intervention analysis revealed an epistemic shift by treatment group compared to control group. Moreover, the treatment group depicted explanatory coherence and seems

to understand the role of justification to claim scientific knowledge. This result of this study attested that engaging students in argumentative group task enhanced their cognitive process to justify and evaluate scientific claims. In addition, to engage students in such discursive activity, enhanced their epistemic discourse.

Using Design Drawings to Formatively Assess Design-Based Science Learning

Hanna Stammes, Delft University of Technology
Ineke Henze-Rietveld, Delft University Of Technology
Erik Barendsen, Radboud University & Open University
Marc de Vries, Delft University Of Technology

ABSTRACT

Engaging science students in design practices can stimulate a wide cross-section of students to develop understanding of science concepts in real-life contexts. To help students develop science content knowledge in the relatively complex setting of design, it is especially important that teachers employ multiple tools and practices for ongoing formative assessment. In this qualitative study, we explore the use of design drawings to elicit and stimulate students' chemistry learning. We found the teacher in our study used the activity of students drawing design ideas to employ informal formative assessment practices based mainly on conversations at the design-team level. But, through talk and glancing over drawings only, the teacher did not elicit many of the chemistry ideas that could be discerned from students' drawings and team talk. Additionally, we found his specific assessment strategies mainly influenced students' design ideas, while their chemistry ideas changed very little (e.g. only in relation to their specific design setting). Based on a discussion of this study's findings, we present possibilities for improved use of design drawings for formative assessment purposes, and give recommendations for teacher professional development activities.

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

Developing students' contemporary practices

10:00 AM-11:30 AM, Salon D

Presider: Mary M. Atwater, University Of Georgia

Moral Reasoning About Human Genetic Enhancement Using CRISPR

Katie Humrick, University of Louisville
Linda C. Fuselier, University of Louisville

ABSTRACT

The purpose of this study was to examine how students with different levels of genetics knowledge and various demographic backgrounds use moral reasoning in the context of non-medical enhancements and CRISPR/Cas9. We used discourse analysis to examine student writing on a class assignment about human non-medical genetic modification using CRISPR/Cas9 technology and we analyzed students' responses using constructed grounded theory. We found that 92% of students were in opposition, 6% were in favor of, and 2% were conflicted about the use of CRISPR/Cas9 for human genetic enhancement. Four main themes emerged from axial coding: the risks (70% of students), eugenics (65% of students), beliefs - religion and authority of nature (50% of students), and human rights (30% of students). We compared the percentage of students from each academic group (non-biology, lower biology, upper biology), SES group (Pell eligible and non-Pell eligible), and ethnic grouping (URM versus majority). URM students were less likely to consider eugenics, beliefs, and human rights in their

responses. Upper biology students were more likely to discuss human rights, but less likely to consider personal beliefs. This work provides insight into how science and morality may be integrated by students from traditionally marginalized communities and at various academic levels.

Patterns of Disengagement: How Students Avoid Discussing Ethics

Eun Ah Lee, University Of Texas at Dallas
Nicholas Gans, University of Texas at Arlington
Magdalena Grohman, University of Texas at Dallas
Marco Tacca, University of Texas at Dallas
Matthew J. Brown, University of Texas at Dallas

ABSTRACT

Participating in authentic research is believed to enhance students' STEM learning. Research and development (R & D) experiences are also good opportunities for students to learn philosophical aspects of STEM, such as understanding the nature of science and technology, seeing values in science, and conducting ethical practices in science and engineering. However, the question of whether philosophical aspects of STEM are learned through R & D experiences has not been closely investigated. This study focuses on how students understand and treat ethics issues while they are participating in engineering design projects. We used a qualitative approach to observe and analyze students' group discussions. We found that engineering students tried to disengage ethics from engineering during their discussions, and we identified eight patterns of disengagement: 1) Deflection to Managers, 2) Deflection to Users, 3) Reduction to Legal Issues, 4) Reduction to Absurdity, 5) Reduction to Triviality, 6) Justification via Observation or Anecdote, 7) Distraction to Technical Details, and 8) Distraction to Non-ethics Issues. These findings imply that students may not be engaging with philosophical aspects of STEM while participating in research or design projects, which is thus a barrier to students' STEM learning. Further attention and exploration are required.

STEM Graduate Students' Development at the Intersection of Research, Innovation, and Leadership

Cindy A. Lenhart, Oregon State University
Jana L. Bouwma-Gearhart, Oregon State University
Judith Giordan, Oregon State University
Rich Carter, Oregon State University

ABSTRACT

Researcher innovation and leadership skills are fundamental to create implementable solutions to pressing societal- and market-based global problems. The Research to Innovation to Society (R2I2S) program is a transformative approach to STEM graduate education, curriculum, and instruction that explicitly trains graduate students at the intersection of research, innovation, and leadership. We detail the design and impact of the program via an exploratory study conducted over a three-year period at one research university in the western United States. The study found that students who participated in the program exhibited enhanced curiosity and motivation towards gaining societal and market insights related to their own and other's research. Students realized the value of thinking about their scientific research from a market research perspective. As well, students developed professional career skills in leadership, collaboration, and communication. We situate our findings in a T-shaped professional framework that values evolving the deep disciplinary skills held by so-called I-shaped professionals into a broader model of professional development in leadership, communication, and assessment of and application of STEM research for solving problems in a market context.

Strand 6: Science Learning in Informal Contexts
Examining Under-represented Young Women's STEM Identities
10:00 AM-11:30 AM, Salon C

Using a Storied- Identity Lens to Understand How Under-represented Women Become a STEM Person
Amal Ibourk, Florida State University
Roxanne M. Hughes, Center for Integrating Research and Learning, NHMFL / FL State University
Clausell Mathis, Florida State University

Exploring Intersectionality and Rightful Presence in Girls' Engineering Experiences in Middle School Science
Edna Tan, University Of North Carolina At Greensboro
Aerin W. Benavides, The University of North Carolina at Greensboro
Angela Calabrese Barton, University of Michigan Ann Arbor

Positioning Girls of Color as Future Scientists: The Implications for Identity Research
Semiha Gun-Yildiz, University Of Massachusetts Dartmouth
Shakhnoza Kayumova, University of Massachusetts-Dartmouth
Akira Harper, University of Massachusetts-Dartmouth

Weaving In- and Out-of-School Experiences to Craft STEM Identities
Carrie D. Allen, University of North Texas

ABSTRACT
Science, technology, engineering, and math (STEM) identity, specifically science identity, has become a popular lens and outcome in science education research. Informal science learning spaces are important spaces to study STEM identity performances and development because they offer youth opportunities to participate in authentic science experiences that include making and learning from mistakes while interacting with diverse role models. This paper set aims to explore how under-represented young women's STEM identities have been and are being studied across different contexts and spaces. This session will focus on findings from four different studies that investigated STEM identities of under-represented young women. Some implications include the design of learning spaces that can bolster participation and sense of belonging for youth in STEM, both out of school and within formalized learning contexts as well as the importance of how looking at STEM identity trajectories among women from under-represented groups is crucial for equity goals of STEM education.

Strand 6: Science Learning in Informal Contexts
Learning science in informal science clubs and camps
10:00 AM-11:30 AM, Salon F
Presider: Heidi Cian, Florida International University

An exploration of youth approaches to community engineering problem definition
Jacqueline Handley, University of Michigan
Elizabeth B. Moje, University of Michigan

ABSTRACT
This study explored the approaches middle-school youth take to the foundational engineering practice of problem definition, from both a disciplinary and a sociocultural perspective. Data were collected with seven youth during an engineering summer program run at a Latinx community organization. Data analysis revealed that the youth in the study approach problem definition largely two ways: They were oriented toward finding a solution quickly, while simultaneously they began to take on the deep technical questioning needed to define problems. This study further suggests that youth bring their everyday knowledges to bear in problem definition, while simultaneously developing technical orientations to the work. Implications of this study support the necessity of informal engineering spaces as contexts to explore youth engineering learning.

Understanding quality learning and teaching in STEM clubs: What does the evidence base tell us?
Angela Fitzgerald, University of Southern Queensland
Kate Davis, University of Southern Queensland
Tania Leach, University of Southern Queensland
Neil Martin, University of Southern Queensland
Shelley Dunlop, Queensland Museum

ABSTRACT
In the Australian context, as well as internationally, STEM clubs are gaining momentum as a means for engaging students in STEM-related activities. Despite this growth, only limited attempts have been made to examine what quality learning and teaching looks like in these informal spaces. This paper addresses that gap through a comprehensive literature review of empirical and practitioner publications on STEM clubs with a focus on understanding approaches to operations, outcomes, and evaluation. The eventual pool of papers was 32 with numerous papers excluded because they explored STEM activities in formalised settings. Through this process, the research team identified three areas that STEM club facilitators need to attend to ensure club success and sustainability – club management, environment, and evaluation. The evidence-based findings presented in this paper can be used by STEM club practitioners to guide their practice to support quality learning and teaching practices. The paper has the potential to provide a holistic perspective of what constitutes quality STEM education more broadly, which could be of use to classroom teachers and teacher educators as they grapple to understand STEM practices. Further, the paper identifies where research is required to explore best practice in informal education settings like STEM clubs.

Using Place as a Primary Resource for Youth Independent Projects at a Wilderness Summer Camp
Eleanor Kenimer, Michigan State University

ABSTRACT
Many have argued for a movement toward place based education (PBE), regarding a localized curriculum as being more meaningful and personalized towards students. Informal learning environments, mainly free of the constraints that formal education has, seem to be perfect environments to incorporate a multidimensional, critical PBE model. Informal environments like summer camps allow for self-guided exploration and learning that can foster youth interest and confidence in STEM. I explored this topic through a case study of a wilderness center summer camp in rural West Virginia, where youth completed an independent project where they were instructed to use the camp as a primary resource. Through this project I show how youth explored a place through a variety of different projects as well as encountered many Disciplinary Core Ideas (DCIs) in science. I assert that their scientific knowledge of DCIs as well as their connection to place and sense of ownership over a

place increased through this self directed project. This has implications for the role informal science education can play in youth's scientific learning as well as how PBE can foster scientific learning, especially when it caters to individual youth interests.

Working Towards Community-Responsive Science Club Programs in Low-Income Communities
Lydia Burke, OISE, University of Toronto

ABSTRACT
Low-income communities in North America contain a high proportion of the demographic groups currently underrepresented in science careers. This study explores the implementation of a localized, research-informed approach to science club programming in a low-income neighborhood. We employed a science identity framework to examine the impact of adapting an existing informal science club program to become more community-responsive, supporting children of senior elementary-age as they develop their identities as science participants. Working with a not-for-profit organization, we conducted research with children, teachers, community leaders, and parents in the target community prior to establishing a science club; this allowed community concerns and interests to be considered during the planning process. The club operated as a weekly after-school program for 20 children aged 8 to 11 and focused on science fun and relationship-building. We found that children in the club readily bridged the formal/informal science spaces, sharing what they were learning in the science club at home and in school. Teachers embraced the complementarity between the program and school-based objectives (which they saw as distinct but collaboratively supportive of the children). We end by considering challenges and opportunities for future iterations of the club and implications for other settings.

Strand 7: Pre-service Science Teacher Education

Making Instructional Decisions: Assessment and edTPA

10:00 AM-11:30 AM, Salon A

Presider: Amity F. Gann, Temple University - College of Education

Increasing Candidate Success on the edTPA Through an NGSS-Aligned Science Methods Course
Wm. Matthew Reynolds, North Carolina State University
Soonhye Park, North Carolina State University
K.C. Busch, North Carolina State University
Gary W. Wright III, North Carolina State University

ABSTRACT
This study investigated how a revised Next Generation Science Standards (NGSS Lead States, 2013) aligned science methods course impacted preservice teachers' (PSTs) performance on the edTPA. Characteristics of edTPA portfolios, both scores and evidence of pedagogical content knowledge (PCK) (Shulman, 1986) from a teacher cohort (N = 6) which took the revised NGSS-aligned science education methods course were analyzed and compared to edTPA portfolios from the previous three cohorts of science education PSTs (N = 33). PSTs' PCK levels were determined by the PCK Map approach (Park & Chen, 2012). The NGSS-cohort scored higher on every edTPA task average, as well as higher on 14 of the 15 rubrics than their predecessors. In addition to gains in edTPA scores, the total PCK connections and, therefore, the strength of PCK was higher for the NGSS-cohort. Evidence of PSTs' Knowledge of Student Understanding, Knowledge of Instructional Strategies and Representations, and Knowledge of Assessments were more frequent in edTPA materials from the NGSS-cohort than had been observed in

the previous cohorts. The findings of this study provide valuable information about how scaffolding PSTs' understanding and implementation of NGSS-practices has the potential to increase PSTs' edTPA performance in addition to promoting inquiry-based teaching methods.

What happens after edTPA? New teachers' views of the value of edTPA experiences

Meghan E. Marrero, Mercy College
Jessica Riccio, Teachers College, Columbia University
Amanda M. Gunning, Mercy College
Latanya Brandon, University Of Connecticut

ABSTRACT

The edTPA, a standardized teacher licensing examination, has become the national gold standard for teacher certification across the United States. The exam is a performance assessment that requires candidates to write extensive responses to prompts, submit video clips of their teaching, and analyze student work. While hailed as more relevant to day-to-day teaching than other performance measures, edTPA can be detrimental to teacher candidates' student teaching experiences, and many candidates fail to recognize the educative benefits identified by the assessment's creators. This qualitative case study of new science and math teachers sought to uncover whether the experience of completing the edTPA influences day-to-day teacher practice. In addition to analyzing interviews, questionnaires, and reflections, the researchers analyzed the teachers' edTPA scores and classroom observation rubric results to triangulate findings. The participants in this study cited edTPA assessment practices, including data-driven instruction, analyzing student work, and providing feedback, and most useful and evident in their practice. Previous studies have found that teacher candidates find the assessment component of the edTPA to be less useful than others, and thus examining this finding more deeply may assist teacher educators in using edTPA structures to better meet the needs of their teacher candidates.

Fostering Informed Design Decision-Making Using Argumentation

Ying Ying Seah, Purdue University
Alejandra J. Magana , Purdue University
Carina M. Rebello, Purdue University

ABSTRACT

Students may not attend to underlying science principles while solving engineering design challenges. Often, they devote efforts towards construction of a working solution by trial and error and don't use reasoning anchored in science evidence to justify their design decisions. It is important to consider argumentation in the process of constructing new knowledge and explanations. This includes argumentation to support claims with evidence and reasoning, as well as developing and refining explanations through evaluation of data. In this study we investigate if the use of argumentation as a meaning-making scaffolding approach during experimentation, facilitated students' generation of informed design decisions while completing a CAD based design challenge. The question was: how does the scaffold of argumentation in science experimentation influence students' design decision-making? 41 students from PHYS 215: Physics for Elementary Education at a midwestern university participated in this 4-week long study. These students were divided into two conditions – with and without argumentation scaffold while science experimentation. Results of this study indicate those in the argumentation condition were able to transfer their argumentation skills to design decision making by demonstrating the ability to justify their decisions using relevant scientific evidence and reasoning, as compared to students without argumentation scaffold.

Strand 8: In-service Science Teacher Education
Argumentation in STEM Education
10:00 AM-11:30 AM, Pearl
Presider: Wonyong Park, University of Oxford

Comparing Teacher and Professional Developer Artifacts to Assess Perceptions of Key Aspects of Argument-Based Inquiry
Andrea Ash, University of Iowa
Mark A. McDermott, University Of Iowa

ABSTRACT
Teachers' understanding of Argument-Based Inquiry (ABI) environments is crucial to their ability to implement them (McNeill & Knight, 2013). Previous studies have examined how teachers understand inquiry environments, with the hopes of using this understanding to better target teachers' needs and adapt future professional development to meet them (Seung, Park, & Jung, 2014). In this study, we widen the scope to examine not only teachers' understandings, but also how the researchers express and perceive features of ABI environments during and after a professional development (PD). Researchers and teachers connected through a three-year PD course; at the end of this period, a third party researcher worked with one of the PD developers to examine the understanding and experience of teachers and researchers based on artifacts collected throughout the three-year time period. While findings suggest that teachers and researchers both came to value the components of an ABI environment, it also appears that the two groups find them valuable for different reasons. Researchers often emphasized the process and cognitive activity inherent in argument, inquiry, and dialogue, while teachers were more likely to name and value products that arise from these aspects. Suggestions for future argument-based inquiry PD are also discussed.

Cross-subject collaboration about argumentation between science and religious education teachers in England: A case study
Wonyong Park, University of Oxford
Sibel Erduran, University of Oxford
Liam Guilfoyle, University of Oxford

ABSTRACT
The research literature on science teachers' continuous professional development has a long history. A particularly challenging aspect of teachers' learning involves conventionally unfamiliar aspects such as the argumentative practices that underpin their subject. While much has been researched about teaching evolution and intelligent design, there is a limited understanding of how professional development of science and religious education (RE) teachers in learning to teach argumentation can be enhanced. This paper primarily aims to illustrate how argumentation can be infused in the professional development of science and RE teachers in unison in order to maximise effective learning of argumentation in general and in relation to issues of science and RE in particular. Through in-depth case studies of two pairs of science and RE teachers, this study illustrates how a professional development project has been engaging the teachers in understanding and teaching argumentation. Data sources included questionnaires, lesson materials, classroom recordings and teacher reflections. The findings indicated that teachers have different understandings of argumentation in relation to their subjects. In addition, the analysis provided evidence that the cross-subject collaboration between science and RE

teachers can occur in at least two distinct modes, each affording different opportunities for teachers' professional learning.

Professional Development for Science Teachers on Socioscientific Argumentation: Examining the Change in Teachers' Knowledge
Bahadir Namdar, Recep Tayyip Erdogan University
Hasan Bag, Recep Tayyip Erdogan University

ABSTRACT
The purpose of this study was to evaluate the effect of an six-day professional development workshops on science teachers' argumentation levels and their perception of teaching socioscientific issues. The participants were 28 science teachers (14 female and 14 male) working across different regions of Turkey. The professional development workshop followed a distributed learning approach and each activity followed claim-evidence-reasoning-rebuttal framework. Each field trip was blended with different teaching strategies. Employing one group pre-test–post-test design, data were collected through argumentation test and an open-ended questionnaire. Results revealed that the PD had statistically significant influence on the teachers' argumentation levels and their perceptions towards teaching SSI positively influenced by the PD content.

Understanding the Impact of Short-Term Professional Development on Secondary Science Teacher's Conceptions of Argumentation Pedagogy
Karen Woodruff, Montclair State University

ABSTRACT
The Framework for K-12 Science Education and the Next Generation Science Standards outline eight Science and Engineering Practices, including Engaging in Argument from Evidence. Pedagogically, facilitating lessons that engaging students in evidence-driven argumentation is a conceptual shift for many teachers. In this study, seventy-two secondary science teachers, seeking professional development with argumentation pedagogies, participated in a one-day workshop at a local university. The researcher, and workshop facilitator collected data through interviews, observations, pre and post surveys, lesson plan review and classroom observation. Through triangulation of data the themes of conceptual change, teacher reflection and collaboration, and planning for implementation of argumentation strategies emerged to advance understanding on how teacher's conceptions of argumentation pedagogy can shift with a brief duration professional development experience. The contribution to the NARST community includes analysis and findings that may help teacher educators and administrators when planning for both workshops and the time following workshops so that teachers receive support for shifting to practices that provide rigorous and equitable learning environments.

Strand 8: In-service Science Teacher Education
Looking Beyond Routines to Study How Teachers Develop Adaptive Expertise with Epistemic Tools
10:00 AM-11:30 AM, Salon B
Discussant: Andy Cavagnetto, Washington State University
Presider: Gavin W. Fulmer, University of Iowa

Looking beyond routine pedagogy to the development of adaptive expertise for immersive argument-based inquiry
Brian Hand, University of Iowa
Gavin W. Fulmer, University of Iowa
Jee Suh, University of Alabama

Developing teacher instruments and protocol to study teachers' knowledge of language, argument, and dialogic interaction as epistemic tools
Gavin W. Fulmer, University of Iowa
Jee Suh, University of Alabama
Brian Hand, University of Iowa
Jihyun Hwang, University of Iowa
Chenchen Ding, University of Iowa
William Hansen, University of Iowa

Developing Adaptive Expertise through a Three-year Professional Development Program: Evaluation of the First Year Program
Jee Suh, University of Alabama
Brian Hand, University of Iowa
Gavin W. Fulmer, University of Iowa
Jale Ercan Dursun, University of Alabama
Krystal Flantroy, University of Alabama

Elementary Teachers' Understandings and Concerns about Epistemic Tools and Adaptiveness: Preliminary Findings from Case Studies
Krystal Flantroy, University of Alabama
Catherine Lammert, University of Iowa
Jee Suh, University of Alabama
Brian Hand, University of Iowa
Gavin W. Fulmer, University of Iowa
Jale Ercan Dursun, University of Alabama
Yejun Bae, University of Iowa
Andrea Malek Ash, University of Iowa

Preliminary Baseline Results of Teachers' Epistemic Orientation and Knowledge of Epistemic Tools
Jihyun Hwang, University of Iowa
Gavin W. Fulmer, University of Iowa
Brian Hand, University of Iowa
Jee Suh, University of Alabama

ABSTRACT
The shift in attention to the epistemic basis of science focuses on helping students learn how scientific knowledge is generated and validated. Learning environments to meet this vision will require teachers move from being providers of knowledge to managers of a knowledge generating environment where students engage with each other to question and figure out scientific phenomena. This also demands that teachers to be more flexible to the sorts of questions, designs, and arguments that students will generate and pose for themselves and each other. The field needs more work to understand how teachers develop more flexibility, or adaptive expertise, for complex learning environments. This related

paper set addresses theoretical foundation and preliminary empirical findings from a research project into how elementary teachers develop adaptive expertise. The project builds on a professional development program that emphasizes immersive argument-based inquiry. This involves new theoretical approaches and with questionnaire, interview, and classroom observation data. Results will be shared on teachers' epistemic orientations and their understanding of the epistemic tools of argument, language, and dialogic learning environments. Findings will also address in detail how teachers adapt their classroom environments to reflect a knowledge generation perspective using case study methods.

Strand 10: Curriculum, Evaluation, and Assessment
Analyzing Real-world Data
10:00 AM-11:30 AM, Columbia
Presider: Molly Stuhlsatz, BSCS

An Exploration of Everyday Contexts of Energy through Online News Article Text Mining
Nam-Hwa Kang, Korea National University of Education
Chi Yeong Oh, Korea National University of Education

ABSTRACT
Analysis of unstructured text data through text mining is one way to use big data for research related to curriculum and instruction. This study explored the possibility of text mining in science education as a way of examining the everyday contexts of a scientific word by applying it to analyzing online news articles on science. The recent popularity of text mining, a way of big data processing, can also be found in education research. As a case study, we applied a text mining technique to examining the everyday context of the term, 'energy'—an important science concept for scientific literacy. For this purpose, 2,497 online news articles from 11 web sites published from March 1 to February 28 in 2018 were collected and for this proposal 487 from three sites were analyzed. Through text pre-processing, a total of 12,079 sentences consisting of 21,116 nouns were compiled for analysis. Term frequency analysis and topic modeling analysis were performed through the R program. Through term frequency analysis, we were able to extract and analyze keywords related to energy. Through a topic modeling called Latent Dirichlet Allocation (LDA), 20 topics were classified, which provides everyday contexts where energy can be meaningfully taught. Implications for curriculum and instruction and further research topics are provided.

Making expertise visible: Transferring the control-of-variables strategy across disciplinary contexts
Martin Schwichow, PH Freiburg
Johanna Kranz, Biology Education, University of Viena
Martina Brandenburger, PH Freiburg
Andreas Nehring, Leibniz Universität Hannover
Peter Edelsbrunner, ETH Zürich
Andrea Moeller, University of Viena, Biology Education

ABSTRACT
The control-of-variables strategy (CVS) incorporates the important domain-general inquiry skills of designing and interpreting controlled experiments. Therefore, CVS is a prominent concept in numerous science standards. It consists of the four sub-skills: (a) understanding the indeterminacy of uncontrolled experiments, (b) planning, (c) identifying, and (d) interpreting controlled experiments. However, studies

on the development of CVS skills are restricted to one or two CVS sub-skills and content form single science disciplines or from everyday life. Our study investigates the effect of CVS sub-skills and disciplinary context on students' CVS performance. The study utilizes an interdisciplinary CVS test developed in a team with colleagues from Biology, Chemistry and Physics education accompanied by experts from Educational Psychology. Each discipline is represented by two contexts (e.g. heat/temperature and electromagnetism in Physics) and each context by one of the four CVS sub-skills: "planning (PL)", "interpreting (IN)", "identifying (ID)", and "understanding (UN)". The data are analyzed with a bi-factorial structural equation model (SEM). The results show that most item loadings on the discipline factors are low or insignificant different from zero while all loadings on sub-skill factors are significant. This finding shows that CVS sub-skills and not disciplinary context influence students' CVS performance.

Measuring the Efficacy of an Approach to Integrating Quantitative Reasoning in High School Biology

Molly Stuhlsatz, BSCS Science Learning
Melissa Kjelvik, Michigan State University
Elizabeth Schultheis, Michigan State University
Brian M. Donovan, BSCS Science Learning
Jeffrey Snowden, BSCS Science Learning
Louise Mead, Michigan State University

ABSTRACT
We report on findings from a cluster-randomized trial of an intervention targeting quantitative reasoning in secondary science. The aim of this study was to investigate the efficacy of flexible activities that engage students in the work of analyzing, interpreting, and explaining data from real-world research contexts. While we did not observe a meaningful difference between treatment and comparison groups on the full measure of quantitative reasoning, we did find that treatment students excelled in the development of a data-based explanation. Students in the treatment condition reported significantly higher self-efficacy around their ability to analyze and interpret data. Relative to the comparison condition, students in the treatment also reported significantly greater motivation to pursue a science career. The NARST community will benefit from a discussion of the targeted activities, including how the intervention builds connections between an authentic study context, providing students with tools to better understand quantitative data, and the development of an explanation. Further, the cluster-randomized trial produced evidence of efficacy that should contribute to the larger conversation about meaningful measures of student content knowledge, self-efficacy, and career motivation.

What do data-based questions really test: Insights from preservice physics teachers' think aloud interviews

Yann S Ong, National Institute of Education, Nanyang Technological University

ABSTRACT
Fostering students' critical thinking is a goal of science education systems around the world. In Singapore, data-based question (DbQ) were included in science national examinations taken by secondary four students (grade 10) to promote higher order thinking. Anecdotally, many science teachers have expressed concern that students do not perform well on DbQs. However, it is uncertain whether DbQs live up to their expectation of evaluating higher order thinking skills and what strategies are needed to answer DbQs. This paper contributes to the existing literature on analyzing cognitive demands in assessments as well as the local need for evaluating DbQs in high stake national

examination. Analysis of a DbQ using revised Bloom's taxonomy (knowledge types and cognitive processes dimensions) is validated by comparing expected codes i.e. analysis based on the wording of items to enacted reasoning i.e. analysis based on reasoning processes evoked when two preservice teachers responded to items. Despite the small sample, findings suggest fairly good agreement between codes generated by the two analytical approaches but also uncovered discrepancies that warrant further investigation by the field. Preservice teachers employed various strategies utilizing contextual cues as well as monitoring one's question interpretation and checking one's responses.

Strand 11: Cultural, Social, and Gender Issues

Centering Race, Whiteness, and Cultural Responsiveness in Science Education

10:00 AM-11:30 AM, Salon H

Presider: Mario Pickens, Georgia State University

Critical Race Theory & Critical Whiteness Studies: Unpacking Preservice Science Teachers' Conceptualizations of Equity

Amber C. Davis, University Of Michigan

ABSTRACT

This small scale qualitative study deploys critical race theory and critical whiteness studies as theoretical grounding to investigate how fifteen preservice secondary science teachers, many of whom are white, reflect on their teaching practice while enrolled in an equity-oriented science methods course. The researcher examines how these preservice teachers conceptualize their own meanings of equity in the context of science education and seeks to identify if and how issues of whiteness, race, and racism emerge in preservice teachers' efforts to be "equitable" in their science teaching. The findings identify ways that preservice teachers' ideas shifted during the science methods course, but more insightfully, ways their ideas and emotions remained consistent. Implications of this study center on the need for explicit deconstructions of whiteness in science teacher education programs in order to truly prepare the anti-racist, culturally sustaining, and equitable science teachers needed to support our nation's increasingly diverse student population.

Stories from the Field: Exploring Culturally Responsive Science Teaching in a Pilot Study

Jamie Wallace, American Museum of Natural History
Elaine V. Howes, American Museum of Natural History Richard Gilder Graduate School

ABSTRACT

This qualitative study is designed to explore teachers' inquiry into and practice of culturally responsive science education in the high-needs schools in which they teach. Through collaborative inquiry with six teachers in a professional learning group, we explore what culturally responsive education (CRE) can look like in science classrooms. We also investigate the intersections between CRE and ways in which teachers enact core science teaching practices that are based on evidence of student learning in their classrooms. We employ an ethnographic approach as participant-observers and use a case study design. Data sources include teacher interviews, group meeting notes, responses to reflective questions, classroom observations, collaboratively designed artifacts, individual teacher artifacts, and samples of student work. This paper focuses primarily on "Stories from the Field,", a routine at each meeting where teachers shared observations, thoughts, and insights about their classroom, instruction, and school settings in the context of CRE. We describe four emerging themes: 1) Teaching in a culturally responsive

space, 2) Systemic constraints (school, administration, state), 3) Making science content and the science learning community culturally responsive, 4) The power of the group.

The Policing Presence of Whiteness in Science Education
Jonathan D. McCausland, The Pennsylvania State University

ABSTRACT
At the core of this paper is the belief that students of Color are marginalized in science. While many studies have attempted to understand this marginalization and others have worked to create transformative learning environments to make science education more equitable, few studies have addressed whiteness. This paper seeks to take up the discourse and ideology of whiteness by examining, through autoethnographic methods, how practices of whiteness existed within my science lab experiences at a primarily white institution in the mid-Atlantic. Using Mensah and Jackson's (2018) notion of science as white property and Thandeka's (1999) concept of white shame, I analyze narratives I have constructed from memory to articulate how whiteness was present during my undergraduate career. Through this analysis, I theorize that science as white property is the result of policing by white authority figures from white zones in to nonwhite zones as well as making other sciences racial others. This work contributes to powerful work on equity and social justice in science education by articulating not just the consequences, but the potential cause and structure of racial marginalization in science education, whiteness.

Upbringing: An equity issue in science teacher recruitment
Mumiah Rasmusen, University College Copenhagen
Bjørn Friis Johannsen, University College Copenhagen

ABSTRACT
In this study we show that among the reasons preservice teachers use to account for their choice to become teachers, they draw on notions of altruism that are ultimately informed by norms and values reflected in their upbringing. These norms and values the students use to identify significant others in the school years – such as important teachers – as significant. The implication is, that not only might teachers choose to teach as they were themselves taught; they might also have their values and norms concerning this teaching informed by their upbringing. If teachers are not representative of the groups of children they are teaching, this might have important consequences for our ability to recruit otherwise underrepresented groups to teacher programs. The study ends by proposing that courses that specifically addresses equity issues among teachers who do not represent the groups of students they are teaching, might help break the issue of misrepresentative recruitment.

Strand 11: Cultural, Social, and Gender Issues

Using Critical Frameworks to Disrupt Deficit Perspectives of Latinx Teachers, Students, and Communities

10:00 AM-11:30 AM, Salon G
Presider: Greses Pérez, Stanford University

Cultivating and Characterizing the Development of STEM Interest Through the Lens of Intersectionality
Deena Gould, Arizona State University
Priyanka Parekh, Transylvania University

ABSTRACT
In this critical design ethnographic case study, we assumed a lens of intersectionality in order to characterize the development of STEM interests among three youth in an after-school STEM club. We co-designed the STEM club, with youth from groups that have been historically marginalized in STEM as design partners, in order to support the youth in growing and developing their own STEM interests. This co-design process afforded the youth access to social and cultural resources of their own choosing in support of their STEM interests. The main purpose of this study was to cultivate and characterize the development of STEM interests from the perspectives of multiply-marginalized youth. Using ethnographic and discourse data, we present a case study of three Latina girls (aged 11 to 14). We characterize how these girls selected and mobilized social and cultural resources and practices related to their intersectional identities in support of expanding and developing their STEM interests over time.

Disparities in biology teachers' expectations for a student science writing activity
Quentin C. Sedlacek, California State University, Monterey Bay

ABSTRACT
Teacher expectations can help to shape student learning outcomes. However, despite the massive research literature on teacher expectations, relatively few studies have attempted to directly measure teacher expectations related to science or to science writing in particular. Such expectations could have important implications for the implementation of new standards and curricular reforms that emphasize the importance of writing in secondary science classrooms. In this study, high school biology teachers (n=70 participants, n=64 schools) in a large U.S. state reviewed a science writing activity and were asked to predict how their students would perform if given this activity. These predictions were regressed on school- and classroom-level student demographics as well as teacher characteristics. Teacher expectations tended to be higher in (1) schools and classrooms with fewer students eligible for free or reduced-price meals; (2) schools (but not classrooms) with fewer students identified as English Language Learners; and (3) schools with higher proportions of White, Asian American, and Pacific Islander students. Possible interpretations of these results are discussed along with implications for research, practice, and policymaking.

Interrupting Deficit Perspectives with Elementary Teachers in a Latinx Community: Reflections from a Collaborative Ethnography
Michelle Brown, Penn State University

ABSTRACT
A growing body of research on emergent bilingual (EB) students in science calls for further examination of students' culture, language, and experiences, and seeks interventions that foster asset perspectives, culturally sustaining pedagogies, and family engagement strategies. Science sense-making can be a powerful instrument to bring people from different sociocultural backgrounds together and to make connections between communities and schools. However, it can also hold hidden assumptions and biases of EB students and families if approached uncritically, ahistorically and through an individualistic lens. This paper investigates how white, monolingual teachers and researchers work to unlearn deficit perspectives of EB students and families from a new immigrant, Latinx community. Insights are shared from a year-long pilot ethnography and a subsequent critical ethnography that work with teachers and EB families through science sensemaking family engagement events, along with personal reflections about deficit perspectives and self-reflexivity.

Using Autobiographies of Latinx Preservice Teachers (LPTs) to Build a Culturally Relevant Instruction
Noushin Nouri, University of Texas Rio Grande Valley
Jair Aguilar, The University of Texas At Rio Grande Valley
Patricia Ramirez-Biondolillo, The University of Texas At Rio Grande Valley
Vero G Frady, The University of Texas At Rio Grande Valley

ABSTRACT
One aim of science education is to develop more equitable undergraduate science learning, including making science more accessible for minorities. Since Latinx students are underrepresented in science (Riegle-Crumb, Moore & Ramos-Wada, 2011), there is an immediate need to consider differentiated instructional approaches in order to increase their engagement in it, especially in Hispanic Serving Institutions (HSIs). To do this, we argue that preparing teachers to teach science in a culturally relevant context by developing their understanding of how sociocultural factors shape both their own and their students' learning is a powerful place to begin. Latinx pre-service teachers (LPSTs) come into education programs as learners with existing cultural understandings and experiences. These can be drawn from and made explicit to produce more culturally responsive teachers, and one way to build a strong foundation of culturally responsive instruction, is to collect and examine LPSTs' autobiographies about their own science education. In this proposal, we therefore present and analyze the results of Latinx pre-service teachers' autobiographical descriptions of their experience with science from early childhood into adulthood, paying specific attention to how their cultures shaped those experiences.

Strand 13: History, Philosophy, Sociology, and Nature of Science
SSI and NOS
10:00 AM-11:30 AM, Portland
Presider: Renee S. Schwartz, Georgia State University

Compassion as a Framework for Understanding and Responding to Socioscientific Issues
David C. Owens, Georgia Southern University
Dana L. Zeidler, University Of South Florida

ABSTRACT
The partisan nature of the current political landscape makes it increasingly difficult for individuals with opposing views to find common ground from which to begin considering and resolving socioscientific issues (SSI). However, given that perspectives from Eastern and Western religions, contemporary culture, and evolutionary science all provide support for the employment of compassion by citizens in their everyday lives, compassion has great potential for serving as such a common ground, but remains understudied. In those investigations that have considered compassion in the context of SSI, the construct was often conflated with other similar constructs, and across studies the manner in which compassion was considered varied. Thus, compassion warrants clarity as a construct. Additionally, it is neither clear what role compassion plays or should play in the consideration of SSI, nor what a progression might look like for learners to practice compassion in the context of SSI. In this theoretical paper, we use conceptual analysis to delineate compassion from its component parts, and offer a framework by which SSI can be considered through a lens of compassion.

Identifying Socioscientific Orientations in the Context of Socioscientific Issues

Dana L. Zeidler, University Of South Florida
Ben C. Herman, University Of Missouri
Melanie Kinskey, University of South Florida
Michael Mitchell, University of South Florida
Selene Y. Willis, University Of South Florida
Karrie A. Wikman, University of South Florida
Tara M. Nkrumah, Arizonia State University
Scott M. Applebaum, University of South Florida
Eunhang Lee, University Of South Florida

ABSTRACT

The purpose of this work was threefold: 1) to examine how science education may benefit from exploring how students epistemological reasoning related elements of social and moral compassion are revealed prior to, and after an academic year engaged in an SSI content rich course; 2) to develop and put forth a standardized rubric for the field that assesses three socioscientific domains, Moral and Ethical Sensitivity, Perspective Taking and Empathetic Concerns, that serve as collective indicators of Social Moral Compassion; and 3) examine the challenges faced by their teacher in establishing a sociocultural norm that engages students in these type of issues. A mixed methods pre – post design was used with data collection occurring at the beginning and end of an academic year. Quantitatively, only moral and ethical sensitivity were found to be statistically significant. However, limitations to quantitative approaches could be observed when qualitative comparisons detected nuanced gains in all three elements trending toward epistemological sophistication. A standardized rubric was generated for assessing gains in all three domains of social and moral compassion. Post course interviews with the teacher highlighted several important points that contain both methodological and pedagogical explanations with implications important to science education.

Promoting active informed citizenry through science education: a stage beyond SSI

Tapashi Binte Mahmud Chowdhury, University of Tartu
Jack B. Holbrook, University Of Tartu
Miia Rannikmae, University Of Tartu

ABSTRACT

This article identifies attributes of SSI through a systematic literature review to build a link between its attributes and the expected role of SSI in promoting, within science education, a desired scientific literate citizenry, able to address worldwide concerns related to sustainable development as declared by the United Nations (2015). It puts forward a conceptual model to address citizenry developments from increasing scientific and technological decisions through constructive activities to address sustainable development at the local, national and global level. The operationalisation of the model builds on the contextualisation, de-contextualisation and re-contextualisation stages, proposed by Holbrook and Rannikmäe (2010), adding a fourth stage termed trans-contextualisation, extending the decision making competence gained in the classroom and seeking to stimulate ways to enact such decisions in practice towards achieving an active informed citizenry.

Socioscientific Topics or Issues, and Why This Distinction Matters: A Critical Review
Nannan Fan, East China Normal University
Sihan Xiao, East China Normal University
Li Ke, University of North Carolina, Greensboro

ABSTRACT
Integrating socioscientific issues (SSIs) into science education has increasingly been viewed as a promising means of engaging students in science and promoting scientific literacy. While SSI-based science teaching is gaining attention, the concept of SSIs is often left uncontested. This review questions the taken-for-granted notion of SSIs. Through a situated lens, we critically look into the SSI contexts and the rationales for selecting these contexts in 40 articles concerning SSI-based teaching published in four leading journals in science education. By comparing different contexts and rationales, we argue that such matters as genetic engineering, global warming, and animal protection are socioscientific topics in which the scientific and the social are potentially brought to bear, but they are not necessarily socioscientific issues that are situated in students' everyday lives and thus actually relevant and problematic to them. The distinction between topics and issues sheds needed light on the connection between the scientific and the social and helps science educators better design SSI-based teaching that fosters scientific literacy.

Concurrent Session 9
2:00 PM-3:30 PM

International Committee
Admin Symposium-International Perspectives on Science Education in Multicultural and Multilingual Contexts
2:00 PM-3:30 PM, Eugene

International Perspectives on Science Education in Multicultural and Multilingual Contexts
Mariona Espinet, Autonomous University Of Barcelona, Spain
Audrey Msimanga, Sol Plaatje University, South Africa
Saouma B. Boujaoude, American University Of Beirut, Lebanon
Alberto J Rodríguez, Purdue University, USA
Sonya N. Martin, Seoul National University, Republic of Korea
Maurício Pietrocola, Universidade de Sao Paulo, Brasil

ABSTRACT
This panel promotes more reflective and agentic approaches to science teacher preparation and science education research. Through the voices of six science education scholars from different parts of the globe and with diverse cultural backgrounds, gender expression and theoretical frameworks, we will instigate a conversation about the complexity of science education in Catalonia, South Africa, Lebanon, South Korea, Brazil and the USA. Next we will critically consider ways to conceptualize and conduct research in multilingual and culturally diverse contexts; the need for more collaboration and research with a focus on equity, diversity and social justice in science education, and the role that policies can play in promoting and sustaining meaningful and productive collaborations with all stakeholders. We encourage discussion about: Cultural and linguistic diversity in science classrooms across the globe Expanding representation of cultural diversity in schools, ethnicity of scholars, and diversity of

scholarship in science education publications Enacting relevant and relational research methodologies that capture the cultural and linguistical complexity of diverse classrooms. Establishing meaningful collaborations with all stakeholders to make research more culturally and socially relevant. Influencing policies related to language learning and use, equitable access and success in education, and research funding

CADASE RIG

Admin Symposium-The African Diaspora Context: School, Community, and Citizenship in Science Education

2:00 PM-3:30 PM, Hawthorne/Belmont/Laurelhurst

The African Diaspora Context: School, Community, and Citizenship in Science Education

Mary M. Atwater, University Of Georgia
Rona M. Robinson-Hill, Ball State University
Terrell R. Morton, University of Missouri - Columbia

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 presentation by an invited speaker including time for a question and answer period. The second part of the administrative session will include a poster session in which faculty members, doctoral students, and preservice teachers from U.S. Historically Black institutions and CADASE and NARST members will share their work that focus on the RIG's theme: The African Diaspora Context: School, Community, and Citizenship in Science Education.

Contemporary Methods RIG

Admin Symposium-Supporting and Advancing Science Education Research Practice through Community Discussions

2:00 PM-3:30 PM, Salon I

Stanley M. Lo, University Of California, San Diego
Francesca Williamson, Indiana Universiity
Glenn Dolphin, University Of Calgary
Joe Taylor, University of Colorado Colorado Springs
Ayca K. Fackler, The University of Georgia
Christa Haverly, Northwestern University
Harini Krishnan, Florida State University

ABSTRACT

The goal of this session is to promote innovative and rigorous research practices in science education research. Our specific objective to advance this goal is to provide methodological support for graduate students and early career scholars in their work around science education research methods. Attendees will engage in roundtable conversations about qualitative, quantitative, and mixed methods research designs. These conversations will also address framing a research project- theoretically, conceptually, and methodologically. More senior and advanced researchers will be on hand during the session to facilitate these discussions and to help provide networking support. Attendees are encouraged but not expected to bring their research related questions, problems, and ideas to discuss.

Strand 1: Science Learning, Understanding and Conceptual Change

Student Understandings about Energy and Light

2:00 PM-3:30 PM, Salmon

Presider: Cari F. Herrmann Abell, BSCS Science Learning

A little knowledge is a dangerous thing: diffraction vs. understanding of rectilinear propagation of light

Estelle Blanquet, LACES, ESPE d'Aquitaine, University of Bordeaux (France)
Violette Blé, Lycée de Langon, Bordeaux (France)
Claire Darraud, XLIM, University of Limoges (France)
Fabienne Goldfarb, Aime Cotton Laboratory, university Paris Sud (France)
Manuela Miron, University of Iasi (Romania)
Eric Picholle, Inphyni,CNRS-Université de Nice Sophia-Antipolis membre Université Côte d'Azur (France)

ABSTRACT

A questionnaire involving 1834 participants from K1 to Master degree level has been submitted in two different countries to identify their representations of light and its propagation inside a closed black box. At one end, a bulb is inserted into a hole drilled in the middle of the box, while three holes are drilled at the opposite end to observe, or not, the light coming out; two compartments are separated by an internal partition pierced with a single 7 mm hole. 70 to 87% of adults fail to predict what they will observe and trace broken or discontinuous lines inside the box. Contrarywise, 82% of very young students make correct predictions. Representations found in most adults do not appear at a significant level (20 %) before 9 y.o. Investigative approaches on the notions of gaze and rectilinear propagation of light, starting at this age, might avoid the permanent installation of erroneous conceptions, which appear to be robust up to adulthood. Insufficient understanding of the diffraction phenomenon introduced in the scientific section of High school seems to lead a large number of abusive uses, not taking into consideration the diameter of the considered holes.

An Elementary Student's Journey to Improved Understanding of Energy

Sara J. Lacy, TERC
Roger G. Tobin, Tufts University
Sally Crissman, TERC
Nick Haddad, TERC

ABSTRACT

We examine how an understanding of energy ideas can develop in elementary school through a close examination of the work of one fourth-grade student over the course of an innovative energy curriculum. Close examination of classroom artifacts collected at three points in the curriculum shows growth in the depth and sophistication of her reasoning, including her ability to connect direct observations (e.g. of speed or temperature) with statements about energy (abstract and unobservable), and her understanding of energy forms, transfer, transformation and flow, in increasingly complex scenarios. As hypothesized in proposed energy learning progressions, her ability to use these distinct but interdependent aspects of energy reasoning to “tell the energy story,” develop in parallel. Key curricular features that support her growing facility with energy reasoning include a consistent analytical framework, the Energy Tracking Lens; a modeling-based stance that supports reasoning both from observation and by inference from the model; the consistent and repeated use of versatile and accessible representational tools; and opportunities for both individual and small-group work.

Developing energy, systems, and fields in middle school – in praise of modest goals

Marcus Kubsch, IPN - Leibniz Institute for Science and Mathematics Education
Sebastian T. Opitz, IPN - Leibniz Institute for Science and Mathematics Education
Jeffrey Nordine, IPN - Leibniz Institute for Science and Mathematics Education
David L. Fortus, Weizmann Institute Of Science
Knut Neumann, Leibniz Institute for Science Education (IPN) Kiel
Joseph S. Krajcik, Michigan State University

ABSTRACT
Scholars have repeatedly criticized the conceptual foundation of forms-based energy instruction. We developed a new approach that does not require forms and builds on the recommendations in the Framework for K-12 Science Education (National Research Council, 2012) and the US Next Generation Science Standards (NGSS Lead States, 2013) to emphasize connections between energy, systems, and fields that mediate interaction-at-a-distance – three complex ideas that are challenging on their own. In this paper we report on a study where we tracked students' learning during two enactments of the approach to investigate how students' usage of systems, transfer, and fields develops over the course of the systems-transfer unit. We found that at the end of the unit, students use systems, energy, and fields ideas in a way that corresponds with a substance-like model of energy which entails a qualitative notion of conservation. While students readily use fields ideas, we found macroscopic fields to be more accessible than microscopic fields. We discuss implications for energy learning progressions, the substance-like model promoting an understanding of conservation, and the utility and accessibility of fields ideas.

Following Students' Conceptualizations of Refraction

Yaron Schur, David Yellin Academic College, Jerusalem, Israel
Ainat Guberman, David Yellin Academic College, Jerusalem, Israel
Svetlana Ovsyannikov, David Yellin Academic College, Jerusalem, Israel

ABSTRACT
Following students' conceptualizations of refraction The object of this multiple case study was to observe students' changing conceptualizations and emotions as they learned about refraction. Five 10th grade students in a small advanced physics class were asked to imagine themselves inside a drop of water and draw their surroundings as viewed from within the drop. The drawing task was performed twice: before and after they learned about refraction. After they had completed their drawings, they were interviewed and asked to explain what their drawings showed and what they had been thinking. In the post-learning session, they were also asked to describe their feelings while they performed the task, and to represent their feelings in an additional drawing. The results show that, despite the uniformity of teaching and tasks, each student had a different conceptualization and underwent a different conceptual change process. The task evoked strong feelings that influenced the students' cognitive performance. It is concluded that students' individual conceptualizations can be readily revealed by asking them to apply their knowledge to unfamiliar contexts and represent the outcome in drawing. Teachers can use this method in class to assess students' individual learning and emotional needs.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Agency

2:00 PM-3:30 PM, Mt Hood

Presider: Heesoo Ha, Seoul National University

Student Opportunities to Enact Epistemic Agency Through Engagement with the NGSS Science and Engineering Practices

Meghan Macias, University of California, Santa Barbara
Elizabeth Arnett , WestEd
Alexis Spina, University of California, Santa Barbara
Ashley Iveland, WestEd
Ted Britton, WestEd

ABSTRACT

This study investigates the opportunities that middle school students have to enact epistemic agency in NGSS-aligned classrooms, drawing upon student survey data, teacher interview data, and classroom observations. We distributed student surveys to investigate student perception of the opportunities they have to engage in the NGSS science and engineering practices (SEPs). We conducted interviews with 19 teachers to determine which SEPs teachers most often incorporated into their instructional practices. Comparison of student survey responses and teacher interview data permitted researchers to examine the origin of science activities in the classroom and the extent to which inquiry began with teachers or students. Findings suggested some inconsistencies between student and teacher reports on how often students enacted epistemic agency when engaging in the three focal SEPs of this study: (1) asking questions and defining problems, (2) planning and carrying out investigations, and (3) constructing explanations and designing solutions. Students reported fewer opportunities to enact their epistemic agency regarding these three SEPs than their teachers did. The full paper will include triangulation of these student and teacher self-report data with classroom teaching observations conducted by the authors.

Shifting Towards NGSS Instruction: Epistemic Agents in Middle School Classrooms

Katy Nilsen, WestEd
Jacklyn Powers, WestEd
Ashley Iveland, WestEd

ABSTRACT

The Next Generation Science Standards (NGSS) involve substantial learning and instructional change on the part of teachers. Although there was a push for teachers to engage their students in hands-on, inquiry-based learning before the NGSS, the shifts in pedagogy required by the NGSS further emphasize that students should be active epistemic agents in directing their own learning. Researchers explored who/what were the epistemic agents in science classrooms and what epistemic agency looked like in these classrooms (N=10). Classroom observation data were collected from several school districts across California in fall 2018. Researchers found that teachers were the primary epistemic agents (9 out of 10 analyzed classrooms) and there was evidence of students being epistemic agents in only half of the observed classrooms. When examining what epistemic agency looked like, researchers noted how in one classroom, when students planned their investigation, they had control over the direction of their learning; however, there was a shift from students back to the teacher once students were carrying out their investigation. These findings indicate that teachers could provide more opportunities to students

to be epistemic agents, but students also need support in engaging in the process of directing their own learning.

Developing epistemic agency: Students' perspectives on and experiences with argumentation during STEM Design Challenges

María González-Howard, University of Texas at Austin
Victor D. Sampson, University Of Texas At Austin
Christina L. Baze, University of Texas at Austin
Lawrence Chu, The University of Texas at Austin
Todd L. Hutner, The University of Alabama
Richard Crawford, The University of Texas at Austin

ABSTRACT
When integrated into classroom instruction in authentic ways, science and engineering practices can allow students to pursue their interests while constructing and using knowledge in ways they deem important. Through such uses, science and engineering practices are promising for supporting students in developing and acting with epistemic agency – taking reign of their learning, and directing how knowledge is constructed and used to explain natural phenomena and to find solutions for problems. However, the promise these practices have for developing students' epistemic agency is greatly limited when students do not perceive these practices as meaningful to their sensemaking work. In this study, we explore students' perspectives of practices, specifically focusing on the science and engineering practice of argumentation, and the relationship between students' perspectives and the epistemic agency they do, or do not, exhibit. This study took place during the pilot of four STEM design challenges in two 8th grade science classrooms. Data sources included student group interviews, and video recordings of four student groups enacting two complete STEM design challenges. Findings revealed the varied understandings that students had about their roles during these challenges, especially in terms of their engagement in argumentation, and the impact these perspectives may have had on the epistemic agency they exhibited.

A Marginalized Student's Epistemic Agency and Associated Conflicts in Small-Group Argumentation in a Science Classroom

Heesoo Ha, Seoul National University
Heui-Baik Kim, Seoul National University

ABSTRACT
This study aimed to explore how a marginalized student attempted to be acknowledged by other participants as one of the epistemic agents in small-group argumentation activities in a science classroom. It also aimed to explore how these attempts were afforded or restrained by the other students in the group. One science teacher and 29 students participated in small-group argumentation activities about photosynthesis. As the focus group, we selected a group that was experiencing conflicts in students' social relationships and that included a student who showed consistent efforts to engage in discussion with the other students. We recorded both the students' discourses during the activities and interviews with the researchers. The records were transcribed for qualitative analysis. From the analysis, we inferred three discursive moves of the marginalized student to be acknowledged as an epistemic agent. The other students' responses varied with their varying interpretations of the marginalized student's epistemological framing and positioning. We described how the students' framings were shared and negotiated during their interactions and how the context of argumentation activity influenced these interactions. This study could offer information for other research that explores how

students negotiate their epistemic agency during interaction in argumentation activity in the science classroom.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Factors Influencing Early Elementary Teachers' Integration of Science and Engineering Practices in Their Classrooms
2:00 PM-3:30 PM, Meadow Lark/Douglas Fir - 3rd floor
Discussant: Katherine McNeill, Boston College

The Role of Context in the Development of Elementary Science Teachers
Elizabeth Davis, University of Michigan
Adam Bennion, University of Michigan
Amber Bismack, University of Michigan

Teacher Learning in a Professional Development for Scientific Sense-making
Amelia Wenk Gotwals, Michigan State University
Kirsten Edwards, Michigan State University
Lisa Domke, Michigan State University
Arianna Pikus, Michigan State University
Blythe Anderson, Michigan State University
Tanya S. Wright, Michigan State University

The Influence of Curriculum Conditions on Teachers' Use of Informational Books in Teaching Science
Alison K. Billman, University of California Berkeley
Bryce Becker, University of California Berkeley
Marjorie Rowe, University of California Berkeley
P. David Pearson, University of California Berkeley

Integrating Scientific Modeling in Elementary Classrooms: Why a PD May Work for Some but not Others
Christa Haverly, Northwestern Unversity

ABSTRACT
The Framework for K-12 Science Education (NRC, 2012) sets ambitious goals for students' learning that integrate science and engineering practices (SEPs), crosscutting concepts, and disciplinary core ideas beginning in kindergarten. In order to create these types of learning experiences, teachers must find ways of involving students in ambitious science learning with a focus on engaging in science practices as they make sense of phenomena. However, teaching science aligned with NGSS is new and challenging for teachers (Tekkumru & Stein, 2015); and it is particularly challenging for elementary teachers who do not have strong science knowledge (Davis, Petish, Smithy, 2006). This related paper set brings together researchers across four projects who are working to support elementary teachers as they integrate SEPs and scientific sense-making into their classrooms. Each paper will describe how they are working with teachers to support their integration of SEPs in the classroom. In addition, the papers will describe the extent to which teachers use the supports and factors that influence the ways in which teachers integrated ambitious science learning opportunities into their classrooms. Following the four presentations, an expert discussant will provide commentary about the papers and facilitate a discussion with the audience.

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

Science across contexts

2:00 PM-3:30 PM, Salon E

Presider: Melody Russell, Auburn University

Physics Teachers' Interpretation of Scientific Literacy in China

Guopeng Fu, East China Normal University

ABSTRACT

This study explores a group of physics teachers' interpretation of scientific literacy in the context of the on-going curriculum reform in China. Drawing upon Sjöström and colleagues' (2017) three versions of scientific literacy, this study employed a Critical Discourse Analysis approach to reveal the power dynamics reflected through physics teachers' interpretation of scientific literacy. The results showed that physics teachers see scientific literacy within the current reform effort as a shift from focusing on knowledge and content to scientific methods and science applications; although some experienced teachers still hold fast to science as an approach for social transformation. Most novice teachers interpret quality education in terms of individual's growth in physics knowledge, skills, and application rather than emancipation. Physics teachers' interpretation of scientific literacy shows the connections between the social/ideological changes in China and teachers' educational beliefs and sheds lights on the implementations of science curriculum reform.

Science and Religious Education Teachers' Views of the Comparison of Argumentation in Science and Religion

Liam Guilfoyle, University of Oxford
Sibel Erduran, University of Oxford
Wonyong Park, University of Oxford

ABSTRACT

Everyday citizens often face problems and dilemmas about which they need to make decisions and choices that impact their everyday lives. Some of these issues are related to the interplay of science and religion. Students' acquisition of argumentation skills has thus emerged as a significant educational goal. Although curriculum standards of school subjects such as science and religious education (RE) include references to argumentation, and teachers are expected to teach to these standards, there is often limited opportunity for teachers of conventionally disparate subjects to express their understanding of how argumentation is broadly conceptualised relative to other school subjects. The primary purpose of this paper is to investigate how science and RE teachers view the nature of argumentation in science and religion, particularly how argumentation is different or similar between them. The data sources are responses from 16 science and 17 RE teachers to a survey consisting of 6 questions analysed for teachers view argumentation in science and RE. The findings include indications that teachers do not view their subjects in conflict. Instead, teachers describe both distinguishing features (such as the forms of evidence acceptable for substantiating a claim) and similarities (such as the structures and processes of argument construction).

Teaching Students with LD and English Learners to Write Mechanistic Explanations
Yewon Lee, University of Maryland, College Park
Susan De La Paz, University of Maryland
Daniel M. Levin, University of Maryland, College Park

ABSTRACT
This study explored whether students with learning disabilities (LD) and those who are English learners (EL) could learn to write scientific explanations when taught via a cognitive apprenticeship approach to instruction. We focus on the scientific concept of causality, which is both central to scientific explanation, and challenging for novices. Three middle school students with LD and three who were EL participated in the study, and we assessed learning outcomes using single-case design (multiple-probe, multiple-baseline) design. After instruction, all participants wrote more nuanced mechanistic explanations, and they wrote more complex sentences while conveying causal relationships in each phenomenon. We also found a substantial improvement in the holistic quality of students' post-instruction writing. Implications for teachers and researchers will be suggested.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Tools and frameworks to measure students' success and struggles
2:00 PM-3:30 PM, Salon C
Presider: Sanlyn Buxner, University Of Arizona

Defining Dimensions of Student Struggle in Undergraduate General Chemistry Lab Activities
Clarissa Keen, University of Massachusetts Boston
Hannah Sevian, University Of Massachusetts Boston

ABSTRACT
Undergraduate general chemistry laboratory curricula have been in flux over the past 30 years with increased calls for proof of effectiveness, debates on instructional style, and questions of student experience/goals. We believe that these questions cannot be answered unless educators and researchers look beyond students' cognitive domain and incorporate the epistemological and socioemotional aspects of the lab environment. This work conceptualizes the student lab experience within the sociocultural framework of activity theory to better understand these variables, discern types of student struggle, and elucidate strategies students employ. Three general chemistry lab activities conducted by multiple lab partner pairs (N=38) were video-recorded and transcribed. These transcripts were analyzed for student interaction in each domain (cognitive, epistemological, and socioemotional). Additionally, interviews were conducted with each participant to gain insight into the laboratory activity system and probe student experience through video recall. The domain-specific struggles identified within this data set manifested as contradictions among the components of the activity theory triangle. Using this framework, we showed where student struggles originated, how the three domains interacted, the ways in which students tried to overcome struggles and their outcomes. These findings have implications for laboratory instruction particularly when designing for teaching 21st century skills.

Innovative Thinking in Science and Engineering Education: The Validity and Reliability of a Modified Tool

Abeer M. Watted, Al-Qasemi Academic college of education
Miri I. Barak, Technion - Israel Institute Of Technology

ABSTRACT

The goal of this study was to establish the validity and reliability of a self-report tool for assessing individual differences in innovative thinking, based on a modification of the 'innovative behavior scale'. The study was conducted among engineering students worldwide, who enrolled in a massive open online course in Nanotechnology and Nanosensors. A five-stage study was conducted to establish the content, construct, and concurrent validity of the innovative thinking scale (ITS), demonstrating stability across populations and over time. The results show that the scale can serve as both a valid research instrument and a reliable self-assessment tool. It can help to evaluate the inclination of learners towards thinking innovatively and to explain individual differences in the kind of innovative thinking that leads to the application of new or significantly improved ideas.

Measuring Student Success as a Latent Variable in Undergraduate Biology Courses

Hannah Huvard, University of Colorado Denver
Courtney Donovan, University of Colorado Denver
Robert M. Talbot, University of Colorado Denver
Chelsey Grassie, University of Colorado Denver

ABSTRACT

In this study, we conceptualized student success as a latent variable composed of four common student outcome measures: (a) cumulative GPA, (b) final course grade, (c) learning gains measured by a concept inventory assessment, and (d) student attitudes towards the discipline measured by an already validated survey. Using student data from Introductory Biology courses, we measured the predictive ability of several demographic, pre-college, and intervention (the use of Learning Assistants) factors on our conceptualized latent variable. Our results indicate that the four common student outcome items used collectively do measure student success as a latent variable. Additionally, several predicting factors (such as age, high school GPA, and the presence of Learning Assistants) were significantly strong predictors of student success as a latent variable.

Testing the Impacts of Data Sources, Magnitudes, and Methods for Developing Biology Early Warning Systems

Roberto Bertolini, Stony Brook University - SUNY
Stephen J. Finch, Stony Brook University - SUNY
Ross H. Nehm, Stony Brook University - SUNY

ABSTRACT

Identifying at-risk students in a timely manner is important for many reasons: deploying targeted educational resources, placing students into optimal course pathways, and engineering group structures for collaborative learning environments. These approaches can help to mitigate well-documented attrition rates, particularly among URM and first-generation students. Although Early Warning Systems (EWS) designed to detect struggling students have used different Data Mining Models (DMM) and institutional datasets, prior work has not explored the degree to which integrating course-specific data with institutional data enhances predictive accuracy and timeliness of course performance predictions. We ran two individual and three ensemble DMMs on 3,225 student records for an introductory biology course encompassing six semesters (2014-17), at four time points (pre-course, weeks 3, 6, and 9) using aggregated course records (2,3,4, and 5 previous semesters). Employing the widely-used AUC metric, we found that the integration of institution- and course-specific corpora generated significantly more power in accurately predicting students' outcomes compared to institutional data alone. We also found that the ensemble method GLMNET obtained the highest performance (AUC: 0.85, Week 3). Our results demonstrate promising approaches for improving the accuracy and timeliness of EWS for introductory science courses.

Which Components of Evidence-Based Teaching Impact Student Learning?:Insights from using PORTAAL for Classroom Observations

Sungmin Moon, University of Washington Seattle
Mallory Jackson, University of Washington, Seattle
Jennifer H. Doherty, University Of Washington
Mary Pat Wenderoth, University of Washington, Seattle

ABSTRACT
Meta-analyses of active-learning research consistently showed that active-learning techniques resulted in greater student performance than traditional lecture-based courses. Based on 225 studies published in peer reviewed journals, active learning was shown to increase student exam performance and decrease failure rates in undergraduate science, technology, engineering, and mathematics [STEM] courses. However, there was not sufficient evidence to determine what type, frequency, or amount of active learning was most effective at enhancing student exam performance. We did not know if there were different impacts of active learning on different student groups, either. In this study, we found that small group activities and instructors' positive feedback were the most effective EBT practices in improving student exam performance. Our study also demonstrated a direct link between implementation of specific elements of EBT methods (type and amount) and a change in student exam performance. Even in low EBT classes, use of EBT methods improved student exam performance. Finally, our study differentiated the effectiveness of specific EBT practices between male and female students, which may provide an important insight about and add more about recommendations for instruction to reduce a gender gap in student achievement.

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

Contemporary instructional approaches in postsecondary STEM

2:00 PM-3:30 PM, Salon D

Presider: Jayson M. Nissen, California State University, Chico

Regardless of major, undergraduates learn when participating in citizen science

Lisa Lundgren, North Carolina State University
Caren B. Cooper, North Carolina State University
Bradley Allf, North Carolina State University
Lincoln R. Larson, North Carolina State University
Brianna L. Johns, North Carolina State University
Sara E Futch, North Carolina State University

ABSTRACT
Citizen science is an important source of data collection and research for informal science learning communities, however, its impact and influence on college students and campuses is understudied. We use the theory of situational interest to highlight how infusing citizen science projects in college courses

can act as a spark that ignites a student's short- and long-term interest. We deployed a 25-question survey to 128 college students enrolled in a conservation resources course at the beginning of the course, then asked students to respond to the same survey at the end of the course. Factor analysis revealed five components within the survey: interest in science, interest in nature, efficacy for science learning, ability in citizen science, and interest in insects. Regardless of major, we found that students showed gains in four of the five factors. This work adds to the burgeoning field of work on citizen science in higher education, showcasing that citizen science projects can affect students' interest, efficacy, and learning.

Student Outcomes in an Concentrated Chemistry Laboratory Course for Online Students

Ara C Austin, Arizona State University
Deena Gould, Arizona State University
Smitha Pillai, Arizona State University
Mary Zhu, Arizona State University
Ian R Gould, Arizona State University

ABSTRACT

We developed an concentrated organic chemistry laboratory course that is equivalent to the conventional semester long organic chemistry laboratory course, in order to accommodate the diverse needs of students in a fully online biochemistry degree program at a large public university. The design of the concentrated course was guided by equivalency theory principles, which suggests that different course formats can be created that provide flexibility without compromising learning, and provide learners with experiences equivalent to conventional courses. The format of the new concentrated course was essentially identical to the traditional semester-long course, except that it was conducted over only 3.5 days. To evaluate the effectiveness of the concentrated laboratory course, we conducted a quasi-experimental study comparing content knowledge, science identity, and motivation factors as outcomes, for students (n= 27) who participated in the 3.5 day concentrated laboratory with students (n= 190) who participated in a conventional 14 week laboratory course. The online students in the concentrated course scored higher in all of the assessed outcomes compared to the conventional students in the conventional course. All of the measured differences in outcomes were statistically significant, with medium to large effect sizes.

Students' Epistemological Views of Socialization and Teacher Support in the Undergraduate Physics Laboratory

Drew J. Rosen, Stony Brook University
Angela M. Kelly, Stony Brook University
Thomas Hemmick, Stony Brook University

ABSTRACT

Laboratory work is a crucial part of a physics learning, and research is necessary to explore student attitudes in different academic settings. This quasi-experimental pilot study compared affective domains of students enrolling in a traditional (in-person) undergraduate physics laboratory course to an at-home, online counterpart. Surveys were completed by 121 students from the in-person and online courses, and factors were identified that described epistemological beliefs about laboratory work and the nature of socialization in the laboratory context. Statistical analyses revealed that students taking the online course perceived significantly more benefits in their physics understandings and connections to physics in other disciplines, however, they were lacking in the social relationships among peers and teaching assistants that the in-person students experienced. In-person students expressed significantly higher positive perceptions of the value of socialization in the laboratory, both in terms of socially constructing scientific knowledge and accessing peers and teaching assistants to further understanding. In-person students also demonstrated more positive experiences with seeking help in troubleshooting experiments and obtaining assistance for technical procedures and data analysis. The results from this study highlight the differences between in-person and online lab courses and may be used to advise students deciding between different laboratory environments.

The Effects of Instructor Classroom Talk on Student Engagement and Reasoning
Abdirizak M. Warfa, University of Minnesota
Petra Kranzfelder, University of California, Merced
Marin Melloy, University of Minnesota

ABSTRACT
Student-teacher interactions are essential feature of active-learning environments that leads to increased incidences of classroom discourse. However, the extent to which teachers are able to engage students in a dialogic discourse depends on the nature of the instructional moves they employ. In this qualitative case study, we examined the discourse behavior of two biology faculty teaching in active learning environments and how their discourse moves intersected with student response levels and reasoning. Our findings suggest both instructors used classroom talk moves that were more authoritative and interactive [e.g., sharing information, evaluating student responses] than dialogic [e.g., involving students in knowledge constructing activities]. Yet, while the incidence of dialogic discourse was overall low (12%), more than 50% of student responses in those instances included reasoning, explanations or justifications that were in-depth and well thought-out. These findings suggest: 1) there is co-relation between teacher discourse moves and students' levels of reasoning; and, 2) teacher discourse moves can be used to orchestrate productive student-teacher interactions, especially in active-learning environments. This work highlights how attending to student-teacher interactions can result better understanding of how faculty instructional moves effect student content engagement.

Strand 7: Pre-service Science Teacher Education
Preservice Teacher Recruitment
2:00 PM-3:30 PM, Salon A
Presider: Meredith P. Thompson, MIT

The Missing Link in Science Teacher Recruitment: STEM Faculty
Elana B. Worth, University of Georgia
Julie A. Luft, University of Georgia
Dorothy Y. White, University of Georgia
Paula Lemons, University of Georgia
Julia E. Przybyla-Kuchek, University of Georgia
Hatice Ozen Tasdemir, University of Georgia

ABSTRACT
The persistent lack of qualified science teachers continues to plague schools. The need for qualified science teachers was evaluated in a region of the southeastern United States. This study focuses on STEM faculty's perceptions: of the education profession, if they advise students about pursuing a career in education, how they approach education career questions, and what they desire to know to increase their knowledge concerning education careers. The data collection process utilized a survey designed for

STEM faculty not directly involved in the education of STEM teachers. The findings highlighted that STEM faculty have a pervasive lack of knowledge concerning the mathematics and science teaching profession, but also many desire to learn more about the teaching profession. In light of these findings, the research team explored ways to enhance the knowledge of faculty about education professions. Two different strategies were identified: meeting with key STEM faculty who work with potential teachers, and capitalizing on opportunities to discuss the education field when STEM and education faculty worked together on projects. This presentation will focus on sharing the process of data collection, findings from this investigation, and implications for establishing and strengthening the connection between STEM faculty and science education programs.

Evaluating Pre-service Science Teachers' Commitment to Science Teaching
Ashley N. Coon, University of Maryland

ABSTRACT
To learn science, students need access to quality science teachers. Unfortunately, there is a shortage of these teachers, due to both low recruitment into and high attrition from science teaching. Tragically, the burden of this shortage – an insufficient or uninspiring science education that precludes the pursuit of the STEM jobs of the future – falls disproportionately upon the shoulders of students from low-income and minority households. Increasing the number of science teachers, then, becomes an issue of social justice. The existing literature on science teacher retention assumes that all science teachers enter the profession committed to a career in teaching, so that attrition from the profession is due entirely to issues that arise after they enter the classroom. In this study of a cohort of pre-service science teachers, I demonstrate that (a) pre-service science teachers enter their preparation programs with varying levels of commitment to remaining science teachers, with some never intending to enter the profession; (b) pre-service science teachers' commitment to remaining science teachers changes throughout the course of their preparation programs, with some crafting exit strategies before graduation; and (c) experiences that occur within science teacher preparation programs contribute to changing commitments to remain science teachers.

Understanding the factors influencing preservice science teachers' decisions to pursue teaching as a profession
Christine V. Mcdonald, Griffith University

ABSTRACT
A central objective of recent government reports focuses on the important role of education in preparing a skilled and dynamic science, technology, engineering and mathematics (STEM) workforce, with effective teaching in secondary STEM classrooms reliant on the engagement and retention of high-quality STEM teachers (Office of the Chief Scientist, 2014). This study sought to explore the factors influencing pre-service secondary science teachers' decisions to pursue teaching as a career. Participants in this study were enrolled in undergraduate and postgraduate teacher education programs at a large, urban Australian university. Analysis of interview data identified two key factors influencing their decisions, including their perceptions and experiences in high school, and a lack of opportunities in STEM-related fields. Other findings indicated participants expressed positive outlooks regarding their decisions to pursue teaching as a career, and articulated views of science and science teaching aligned with inquiry-based approaches in science education. Implications from this study suggest that, although these participants are likely to encourage students to consider teaching as a profession, they may not promote STEM-related professions as possible career paths, due to their previous experiences.

Strand 8: In-service Science Teacher Education

Equity and Elementary Science Teaching & Learning

2:00 PM-3:30 PM, Salon B

Equity and Elementary Science Teaching & Learning

Jessica J. Thompson, University Of Washington
Carla Zembal-Saul, Pennsylvania State University
Christina V. Schwarz, Michigan State University
Heather J. Johnson, Vanderbilt University
Gail Richmond, Michigan State University
Shakhnoza Kayumova, University of Massachusetts-Dartmouth
Melissa Braaten, University Of Colorado - Boulder
Déana A. Scipio, IslandWood
Kristin L. Gunckel, University Of Arizona
Jessica Lee Chen, Teachers College, Columbia University

ABSTRACT

Teachers often face a conundrum when trying to enact equitable practices that likewise support substantive learning opportunities. This session examines a set of projects that attend to culturally and linguistically sustaining science teaching principles and practices that ground teacher learning in elementary students' cultures, identities and lived experiences. The goals of this session are to a) elaborate forms of science teaching practice that support equitable opportunities for substantial learning, b) examine teacher learning agendas supporting these practices, and c) strengthen equity research agendas across projects. We examine a diverse set of empirical findings and theoretical lenses and ask: 1) What are the underlying assumptions of featured equitable practices in each study?, 2) How can equitable principles be recognized/practiced?, and 3) What are the affordances for student learning?

Strand 8: In-service Science Teacher Education

Professional Learning Communities

2:00 PM-3:30 PM, Pearl

Presider: Wisam Sedawi, Ben Gurion University

Exploring Secondary Science Teachers' Engagement Within a Professional Learning Community During Instruction on Evolution

Margaret M. Lucero, Santa Clara University

ABSTRACT

Many educators and researchers argue the benefits of science teachers being afforded the opportunity to participate and collaborate within professional learning communities (PLC), especially when preparing to teach conceptually difficult science topics. However, there exists little research that explores how teachers' participation and engagement within a domain-specific departmental PLC influences their instructional practice during instruction on a difficult science topic like evolution. By using an exploratory qualitative methodology and applying a framework for teacher leadership, this study reports an attempt to describe the influence of PLC practice by triangulating PLC meeting events with multiple teacher interviews and classroom instruction so that it may provide insight into how a group of biology teachers navigate the nuances between group decisions and individual instructional practices.

Keeping it Going: Roles Teachers Take on to Support Ongoing Science Professional Development
Julianne A. Wenner, Boise State University
Sara Hagenah, Boise State University

ABSTRACT
In order to make substantial instructional shifts in science education, teachers must be provided with effective professional development (PD) that will support them through this transition. The key components of effective PD include things such as a content focus, active learning, coherence, and duration. However, we argue that there is a large omission from this list: the PD participants themselves. This study examines the roles taken on by teachers that helped move a two-year PD experience forward. Our data indicate that five roles (Materials Managers, Tool Makers, District Bridgers, Endorsers, and Servant Leader) were key in moving the science PD forward in the absence of the PD providers. PD providers generally acknowledge that they must respond to the needs of their participants; this work digs into the details of how PD providers might continue to be responsive to context and be thoughtful about the types of roles they might encourage in their participants in their absence.

Science Teachers' Professional Vision of Students' Motivation to Learn: Assessment and Implications
Wisam Sedawi, Ben-Gurion University Of the Negev, Israel
Dana Vedder-Weiss, Ben-Gurion University Of the Negev, Israel
Hasida Yakobov, Ben-Gurion University Of the Negev, Israel

ABSTRACT
Science education scholars are calling for increased attention to declining student motivation to learn science. However, only scarce research focuses on the role of teachers' professional perceptions and knowledge in supporting student motivation. In this study, we investigate science teachers' professional vision of students' motivation to learn science by analyzing their on-the-job discussions during teacher team meetings. We focus on their discourse about student motivation in these discussions, examining the frequency of such discussions, duration, content, and focus. Twenty meetings were audio-recorded from three science teacher teams in three different elementary schools, and analyzed through systematic coding. Preliminary findings indicate that elementary school science teachers' professional vision of their students' motivation to learn is limited. In most cases, student motivation is not the focus of their discussions but, rather, addressed only briefly in relation to other topics. Moreover, teachers tend to focus on their instructional methods, predominantly addressing motivational issues from their practical perspective and only seldom considering them also from students' perspectives and accounting for internal factors as well. The results highlight the affordances and constraints of on-the-job professional discussions for developing teachers' motivation-related professional vision, and for enhancing opportunities to collaboratively learn about science students' motivational problems.

Teachers' Learning Communities as a Framework for Promoting Changes in the Instructional Physics Lab
Smadar Levy, Weizmann Institute of Science
Zehorit Kapah, Weizmann Institute of Science
Esther Magen, Weizmann Institute of Science
Edit M. Yerushalmi, Weizmann Institute of Science

ABSTRACT
Reforming the instructional science lab to foster an inquiry-oriented lab means tackling the powerful structural constraints enforced to preserve the widespread "cookbook" lab approach. We examined

Professional Learning Communities (PLCs) of physics teachers (N=225) as a means of promoting large-scale change in the instructional physics lab. A survey administered in the PLCs revealed significant differences in the goals teachers value as compared to their satisfaction with the manifestation of these goals in national lab exams, as well as their perceptions of students' work in the instructional lab versus work conducted by experimental physicists. The identified discrepancies in teachers' views led to the design of inquiry-oriented activities to meet the teachers' needs and cope with structural constraints. The activities focused students on the considerations that underlie the design of experimental setups that they encounter in the lab. The teachers experienced the activities as learners and then enacted them in their classrooms, reflected collaboratively on their experiences, and discussed the challenges they faced. A post-intervention survey showed that half of the teachers introduced inquiry-oriented components into their lab lessons. They perceived the changes to be feasible despite being confronted with the structural constraints that make it so difficult to implement change.

Strand 10: Curriculum, Evaluation, and Assessment

Attitudes, Beliefs, Motivation, and Identity in Science Learning

2:00 PM-3:30 PM, Columbia
Presider: Claire Cesljarev, Indiana University

A 12-Item Survey to Measure

Linda Morell, University Of California, Berkeley
Shruti Bathia, University of California Berkeley
Ben Koo, University of California, San Francisco
Rebecca Smith, University of California, San Francisco
Mark R Wilson, University of California, Berkeley

ABSTRACT
Only six percent of all 24 year olds in the US have completed undergraduate degrees in one of the STEM disciplines (Hrabowski, 2011). The percentages are even lower for underrepresented youth. In an effort to increase the number of minorities and women entering these fields, especially science, and assist in the prevention of students leaving these fields, educators have started to develop interventions. To determine students' attitudes about themselves in research, valid tools are necessary. To address this need, we developed a 12-item survey. The survey addressed four aspects of researcher identity. Those dimensions are (1) Agency, (2) Community, (3) Fit and Aspiration, and (4) Self; and "a researcher" was defined as someone who conducts an organized and systematic investigation on a topic or question related to a scientific field. After several iterative cycles, 863 high school students were administered the survey, and Rasch scaling was used to analyze the data. Item fit, item design, content validity, external validity, internal consistency, reliability, and fairness (including DIF) regarding the survey are presented.

Are science education attitude instruments conceptually robust? A systematic review of 2004-2018 literature

R. Bogdan Toma, Universidad of Burgos
Norman G. Lederman, Illinois Institute Of Technology
Jesús Ángel Menéses Villagrá, Universidad of Burgos

ABSTRACT
In recent years, a growing body of attitude measurement instruments have been published in the science education literature. This study examines the conceptual framework of 62 instruments retrieved

from the Web of Science and Scopus databases following the PRISMA criteria for systematic reviews. More specifically, this study investigates how the attitude construct is conceptualized in published science education measurement instruments and whether the proposed instruments were rooted in any existing attitudinal theory. Taken together, the results suggest that rigorous and conceptually valid attitude instruments are still lacking in science education research. Most reviewed instruments lacked theoretical underpinning, were mostly develop upon existing instruments with conceptually poor definition of the attitude construct, and presented a broad spectrum of constructs within the attitude umbrella, from beliefs to interest, emotions or engagement. This findings highlight that a greater conceptualization and concretion of the attitude toward science construct is required.

Assessment of Attitudes Towards Evolution and Understanding of Evolutionary Processes and Concepts Across Europe

Anna Beniermann, Humboldt University of Berlin; Institute for Biology
Paul Kuschmierz, Justus Liebig University of Giessen; Institute for Biology Education
Dittmar Graf, Justus Liebig University of Giessen; Institute for Biology Education

ABSTRACT

The assessment of acceptance as well as understanding of evolution is a central issue for science education research. Most international comparative surveys that aim to measure acceptance of evolution or understanding of evolution collect data by use of one single-item in the form of a multiple-choice question that often compounds different constructs in one question. Until now, no international comparative study has been performed to compare the state of evolution acceptance and understanding by means of multi-item instruments. Additionally, there is no consensus on the nature of the relationship between evolution acceptance and evolution understanding within the evolution education community, even if it was shown that different evolution acceptance measures lead to diverging results. We developed a questionnaire to assess acceptance and understanding of evolution as well as religious faith within a European research network (EuroScitizen COST Action) and administered it to university freshmen across 22 European countries. In doing so, we aim to provide comparable data that can help to clarify, if the relationship between evolution acceptance and understanding differs between the participating European countries with their varying cultural backgrounds. Furthermore, these results will give information about the state of knowledge and acceptance of students who all recently finished secondary education. The networking for this work has been funded by EuroScitizen COST Action (CA17127 – http://www.euroscitizen.eu/).

Measuring Students' STEM Identity: Adaptation of an Engineering Identity Survey to the Broader Context of STEM

Kelli Paul, Indiana University
Adam V. Maltese, Indiana University

ABSTRACT

Due to the underrepresentation of women in STEM fields, attention recently has been paid to understanding how and why individuals develop a science identity (generally) as well as specific career-related identities (e.g., engineering and physics identity). More educators and outreach providers are trying to engage students, especially at the elementary level, in the broader notion of STEM. A survey to assess STEM identity more generally would provide educators and outreach providers a means of describing as well as documenting changes in students' STEM identity over time. We previously developed a survey to assess students' engineering identity. We believed that these engineering identity constructs would be applicable and hold within a broader context of STEM. We decided to test the

survey for how well it would work if we replaced the term “engineering” with “STEM”. Our findings suggest that the STEM identity version provides consistent results as the engineering identity serve and thus has potential application in the context of STEM more generally.

Strand 11: Cultural, Social, and Gender Issues

Commitment to Equity & Social Justice for Girls and Women of Color in STEM

2:00 PM-3:30 PM, Salon H

Presider: Felicia Moore Mensah, Teachers College, Columbia University

Black girls as activists and civil agents: Promoting STEM for social justice

Natalie S. King, Georgia State University

ABSTRACT

This presentation highlights the rich contributions and civic engagement of Black middle and high school girls who navigated through the constraints of poverty to transform their local and global communities. Utilizing the Multidimensionality of Black Girls’ STEM Learning conceptual framework (King & Pringle, 2018), we explored the expressed civic identity and enactment of youth activism through community-based initiatives. Positioned as civic agents, Black girls collectively resisted injustice by providing solutions to systemic issues to promote social change. Their projects were interconnected and centered the challenges of living in a food desert, thus providing solutions to the issue for the community’s benefit and overall well-being. This case study sheds light on the importance of creating counterspaces where Black girls can problematize deficit notions, establish and maintain intergenerational relationships, and validate one another's experiences as important knowledge. In these spaces, they can engage in social justice work and grapple with how their Blackness and girlhood inform their civic engagement and leadership efforts.

Creating Nuance for Black Girls' Science Alignment Using the CLIC Framework

Ashley N. Jackson, University Of Michigan

ABSTRACT

This proposed stand-alone paper provides insight into how Black girls operationalize their identities around race, gender, and class. Using the Content Learning and Identity Construction (CLIC) framework, I explore how these identities overlap with academic and disciplinary identities to inform Black girls’ alignment with science. The findings reveal that context influences how Black girls’ identify and align with science, and the particular identities that they bring to bear. Social class emerges as an important factor in thinking about resources and the types of identities that girls do and do not draw upon. Additionally, socialization impacts Black girls; perceptions of what it means to be a Black girl and influences their ideas of what it means to do science. This work has implications for science identity as well as furthering the CLIC framework to include gender and class in addition to race.

How a "Judgement Free" Space Influences African American Girls Sisterhood and STEM Identity

Faith Freeman, University of North Carolina at Greensboro
Edna Tan, University Of North Carolina At Greensboro

ABSTRACT

African American girls are almost nonexistent in Science, Technology, Engineering, and Mathematics (STEM-) spaces. Many African American females find STEM spaces as White, masculine, and uninviting.

African American girls need to be in spaces where they can actively engage; spaces that value their voices and foster collaboration among everyone. There are many beneficial impacts informal STEM experiences can bring to AA girls, such as increasing their interests and sense of competencies in science and engineering. This study takes up the notion of such "judgment" AA females may face while engaging in STEM and explores how a "judgment-free" (free of oppressive judgment) STEM space in an informal, community club can affect AA females' identity work.

Talking about Systemic Racism in Science Teacher Education
Felicia M Mensah, Teachers College, Columbia University

ABSTRACT
Discussions of race in science teacher education can begin to illuminate why educational equity is needed for students in K-12 science classrooms and how graduate education may support educational change. However, the educational experiences of science education doctoral students learning about issues of race in science education has to be understood within the larger context of how institutional racism also works in education. This study speaks to elements of theory, practice, and research with an emphasis on understanding race in teacher education which has implications for science teacher education. Selected for this study were nine Women of Color science education doctoral students. They were diverse in terms of racial and ethnic backgrounds, age, and teaching experiences and were interested in becoming science teacher educators. The study reports on participants' learning in a 16-week doctoral level course that addressed issues of race and racism in teacher education. Using an array of instructional approaches in the course, student artifacts from the course were collected and analyzed as data for this study. Their artifacts (writings based upon course content and discussions) served as reflective notes, capturing their thoughts about systemic racism in teacher education. Implications for science teacher education are discussed.

Strand 12: Educational Technology
Technology-Enhanced Framing of Data to Facilitate Classroom Enactment of Science Practices
2:00 PM-3:30 PM, Salon G
Discussant: Scott McDonald, Pennsylvania State University
Presider: Hee-Sun Lee, The Concord Consortium

Tracking Students' Data Collection from a Simulation Model: Teacher Framing and Student Variations
Gey-Hong Gweon, Physics Front
Hee-Sun Lee, The Concord Consortium
Scott McDonald, Pennsylvania State University

Small Group Reasoning about Unexpected Sensor Readings When Scaffolded (or Not): One Physics Lesson, Four Teachers
A. Lynn Stephens, The Concord Consortium
Tom Farmer, The Concord Consortium
Daniel N. Damelin, The Concord Consortium

Computer-aided Collaborative Learning
Paul Horwitz, The Concord Consortium
Cynthia McIntyre, The Concord Consortium

Jessica Andrews-Todd, Educational Testing Service

Can a Pedagogy of Learner Agency and the Internet of Things Improve Science Classroom Learning and Culture?
Sarah Haavind, The Concord Consortium
Sherry H. Hsi, The Concord Consortium

ABSTRACT
In science, data play a central role in testing knowledge-based hypotheses, exploring new phenomena, and developing explanations of phenomena under investigation. While the Next Generation Science Standards (NGSS) strongly support the integration of disciplinary core ideas with science practices, how to design and enact data-rich classroom activities remains a challenge. The purpose of this session is to delineate and demonstrate how various types of technologies can provide data-intensive contexts to support a range of science practices such as using models, planning and carrying out investigations, analyzing and interpreting data, communicating information, and using computational thinking. This session consists of four papers that feature student activities designed for high school and college students in physical and biological sciences. Technologies addressed in this session include data visualizations, simulation models, an experimentation entropy tracking engine, an interactive data collection and analysis platform, an online collaborative simulation environment, and interactive sensor data flow controls. This session will inspire ways in which technologies can frame data exploration, collection, use, and analysis appropriately for target students in disciplinary contexts and across science practices.

Strand 14: Environmental Education
Fostering Young Learners' Socioecological Systems Reasoning and Decision-Making through Family and Community Supported Field-Based Science
2:00 PM-3:30 PM, Portland
Discussant: Sarah Stapleton, University of Oregon
Presider: Leah A. Bricker, Northwestern University and The Spencer Foundation

Complex Socioecological Systems, Nature-Culture Relations, and Field-Based Science: A Model for Early Childhood Science Education
Megan Bang, Northwestern University
Carrie Tzou, University of Washington Bothell
Christine Benita, Seattle Public Schools
MaryMargaret Welch, Seattle Public Schools
Sharon Siehl, Tilth Alliance

An Analysis of Young Children's Socioecological Sensemaking
Priya Pugh, University of Washington
Megan Bang, Northwestern University
Carrie Tzou, University of Washington Bothell
Jordan D. Sherry-Wagner, University of Washington
Leah A. Bricker, Northwestern University

Wondering in Places: Culture, Ethics, and Complexity in Early Science Education
Jordan D. Sherry-Wagner, University of Washington
Megan Bang, Northwestern University
Carrie Tzou, University of Washington Bothell

Leveraging Place-Based Science to Mediate and Transform Teacher, Family, and Student Relationships
Charlene LaDawn Montaño Nolan, Western Washington University
Megan Bang, Northwestern University
Carrie Tzou, University of Washington Bothell

ABSTRACT
This related paper set reflects increased global need for science education that attends to ecological systems and interactions between natural phenomena and human communities, or socioecological systems. This set of papers explicate the details of a project that seeks to co-design (with classroom educators, families, and community-based organizations) classroom learning engagements that support young science learners in Kindergarten to 3rd grade with equitable, culturally-based, socioecological systems learning and sustainable decision-making using field-based science education in outdoor places (e.g., gardens, parks, neighborhoods). The pedagogical model incorporates students' observations and wonderings, family cultural and community practices, and critical historicity of place. We begin with a paper that overviews the project's foundational design principles, rationales, and pedagogical model. The three papers that follow highlight three empirical analyses situated in different aspects of the project. NARST members who are interested in environmental sciences, early childhood science education, field-based science methods and practices, and models of co-design of learning environments, in addition to how elements of power and historicity intersect with science learning and teaching, should find this session compelling.

Concurrent Session 10
3:45 PM-5:15 PM

Research Committee
Admin Symposium-Impacting Practice through Science Education Research: Communicating Within and Across Places, Contexts, and Communities
3:45 PM-5:15 PM, Salon I

Impacting Practice through Science Education Research: Communicating Within and Across Places, Contexts, and Communities
Carrie D. Allen, University of North Texas
Mary M. Atwater, University Of Georgia
Anne E. Emerson Leak, High Point University
Norman G. Lederman, Illinois Institute Of Technology
Stanley M. Lo, University Of California, San Diego
Stefanie Marshall, University of Minnesota
David C. Owens, Georgia Southern University
Christina Siry, University Of Luxembourg

ABSTRACT
The Research Committee invites doctoral students, early and mid-career scholars, and veteran researchers to participate in this interactive and instructive session aimed at promoting a dialogue about the NARST mission to improve "science teaching and learning through research." Bringing together eight notable scholars who actively contribute to the NARST Organization in varying ways, the purpose of this session is two-fold: (1) Examine how the impact of our research is shaped by the structures present in our community of science education researchers – including the enactment, dissemination, and audience of our scholarly works. This phase of our session provides a space for panelists to draw from their experiences and connect to their own work, and then respond to questions provided by the organizers; and (2) Contribute to an ongoing dialogue about impact as a laudable goal. During this phase, small groups of panelists and facilitators will engage in discussion with attendees about issues relevant in our community; considering strategies for having a particular kinds of impact, accentuating the connection to practice. Attendees with leave with philosophical, conceptual, and pragmatic examples of ways that research can be impactful, as well as comments from panelists on how to support science teaching and learning "across places and contexts" through their personal research agendas.

International Committee

Admin Symposium-Promoting an International Focus on Research and Science Teacher Education to Improve Science and Special Education

3:45 PM-5:15 PM, Eugene

Promoting an International Focus on Research and Science Teacher Education to Improve Science and Special Education

Sonya N. Martin, Seoul National University, Republic of Korea
Ileana M Greca, Universidad de Burgos, Spain
Eva Silfver, Umeå University, Sweden
Ying-Ting Chiu, The Ohio State University, USA
Da Yeon Kang, Seoul National University, Republic of Korea
Sungmin Im, Daegu University, Republic of Korea
Jeongho Daniel Cha, Daegu University, Republic of Korea
Scott Cohen, Georgia State University
Patrick J. Enderle, Georgia State University
Renee S. Schwartz, Georgia State University

ABSTRACT
This panel/symposium seeks to promote more reflective and agentic approaches to science teacher preparation and science education research focused on improving science teaching and learning for students with Special Education Needs (SEN). Through the voices of 10 science education scholars from different parts of the globe and with diverse research contexts and expertise, we will engage in a dialogue about science and special education and we will encourage audience participants to reflect on and discuss the following questions: (a) What is science teaching and learning like for SEN students in my local contexts?; (b) How are teachers being prepared to effectively meet the science learning needs of SEN students?; (c) What research is being done to improve science teaching and learning opportunities for SEN students?; (d) What can be done to expand our focus on special education and science education as an organization? Drawing from the experiences of the panelists special education and science education in different contexts, we will encourage the audience participants to self-reflect on

the ways they could promote improved science teaching and learning for all students.

Graduate Student Committee

Admin Symposium-Graduate Student Research Symposium

3:45 PM-5:15 PM, Hawthorne/Belmont/Laurelhurst

Graduate Student Research Symposium
Ayca K. Fackler, University of Georgia
Christa Haverly, Northwestern University
Kathryn Green, University of Georgia
Melanie Kinskey, University of South Florida
Sina J. Fakoyede, University Of Witwatersrand
Jessica Karch, University of Massachusetts Boston
Timothy Klavon, Temple University
Jose Pavez, University of Georgia
Shelby Watson. University of Mississippi
Klaudja Caushi, University of Massachusetts, Boston
Caroline T Spurgin, University of California, Santa Cruz
Daniel Pimentel, Stanford University
Anne McAlister, University of Virginia
Jordan Bader, University of New Hampshire
Stephanie Eldridge , University of Georgia
Kirsten Edwards, Michigan State University
Mohammed Estaiteyeh, Western University
Chelsea Sexton, University of Georgia
Hannah Huvard, University of Colorado Denver
Scott Cohen, Georgia State University
Johannah Crandall, Washington State University
Sarah Lilly, University of Virginia
Caitlin Fine, University of Colorado, Boulder
Clarissa Keen, University of Massachusetts, Boston
Catherine Cullicott, Arizona State University
Anna Gillespie-Schneider, University of Georgia
Laura Zeller, University of Illinois at Chicago

ABSTRACT
The purpose of this poster session is to support graduate students as they develop their research projects by allowing them to present works in progress and receive feedback from scholars. Attendees are encouraged to provide feedback and support the growth and development of graduate student scholars.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Argumentation & Sense-Making

3:45 PM-5:15 PM, Mt Hood
Presider: Andy Cavagnetto, Washington State University

Examining Dynamics that Contribute to the Initiation and Sustenance of Sensemaking in Science
Harini Krishnan, Florida State University
Lama Jaber, Florida State University
Jennifer Schellinger, FSU
Sherry A. Southerland, Florida State University

ABSTRACT
Reform efforts suggest that science learning should be a sensemaking enterprise that positions students to construct and evaluate scientific explanations of phenomena. What factors contribute to student engagement in scientific sensemaking and what sustains this engagement are emerging questions. This study adds to research that explores these questions by examining and comparing the dynamics that contribute to engagement in scientific sensemaking in three groups of eighth grade biology students. Data include audio and video recordings of small group discussions, student artifacts, and stimulated-recall interviews. Our findings identify that the ambiguous nature of the task as well as teacher-student and student-student interactions alone cannot initiate and sustain sensemaking. Rather, the dynamic interactions of these factors intertwined with social and affective elements are needed to trigger and maintain sensemaking. This study contributes to the repertoire of factors typically considered in fostering productive disciplinary engagement in science.

Use of Evidence in Arguments about Scientific and Near-Scientific Issues
Minghui Zhu, East China Normal University
Sihan Xiao, East China Normal University

ABSTRACT
While the use of evidence is central to developing and countering scientific arguments, students face a variety of troubles perceiving, understanding, and deploying evidence. To address this problem, many researchers have started to argue for a more social view of the use of evidence, among other epistemic practices in the science classroom. This study expands this growing body of scholarship by focusing on not just what evidence is used, but also how evidence is dialogically constructed, understood, taken up, and transformed in the moment-by-moment interaction and how it functions in students' ongoing arguments. Taking Bakhtinian theories as an analytic lens, this proposal reports on a comparative case analysis on video data in which middle school students in Shanghai used evidence to support their claims and refute those of others in two different task contexts: scientific and near-scientific issues. Analyses reveal that students used different types of evidence, and the ways in which they transform social discourses into evidence varied across contexts. This study sheds critical light on curriculum design and teaching practice that facilitate productive engagement in scientific arguments.

Elementary Students' Epistemic Processes on the Earth Revolution and Apparent Motion of Constellations: Practical Epistemology Analysis
Seungho Maeng, Seoul National University of Education

ABSTRACT
From the view of epistemic practice, this study sought to examine how elementary students construct explanation about Earth revolution using practical epistemology analysis. To this goal this study was conducted at two elementary science classes. After observing four celestial maps taken from Stellarium for three months, students discussed how and why the constellations such as Libra, Virgo, Corvus, and Crater (or the Cup) moved and if the Earth moved which direction the Earth went through. Result of

practical epistemology analysis showed that students were able to infer the apparent motion of constellations contingent on the Earth revolution with heliocentric descriptions. At the same time they had geocentric view by which stars of the constellations move along with our eyes. With regard to epistemic process, therefore, they had difficulty in understanding of the direction of the Earth revolution in spite of their prior knowledge of anticlockwise motion and exact observation of the apparent motion of constellations. Two epistemic barriers of interpreting observed astronomical data in two-dimensions, and of interpreting the direction of stars' apparent motion with geocentric view were discussed to improve elementary students' understanding of the Earth revolution as epistemic entity.

Influence and Characteristics of Small Group Argumentative Dialogue in Large Lecture Biology
Andy Cavagnetto, Washington State University
Erika Offerdahl, Washington State University
Jessie Arneson, Washington State University
Larry Collins, Washington State University
Jacob Woodbury, Washington State University
William B. Davis, Washington State University

ABSTRACT
While considerable research has been done on argumentation in K-12 settings, few studies have systematically examined argumentation-to-learn instruction in large lecture hall courses. This paper reports on a study of an argumentation-to-learn intervention in a large lecture biology class with fixed stadium style seating. Drawing on Asterhan & Schwarz's argumentation to learn framework, we examine how students interpretations of primary data change from pre-class activities through multiple rounds of argumentative contexts. Discourse analysis is then used to provide information on how the opportunities for argumentation are being leveraged by small groups. Results show that with minimal frontloading of content students accuracy of interpretations do improve over multiple opportunities for small group argumentative dialogue. Interestingly there was no change in accuracy of interpretations after the first opportunity for small group argumentative dialogue. Preliminary analysis of discourse shows that students are consistently on task. Justifications were common but they often drew verbatim from the materials provided during the argumentation session. More broadly, prelminary analysis suggests that groups are not taking time to interrogate a collective position, rather the scribe tends to have a lot of power in generating the group's final interpretation.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
The Effects of Children's Media on Preschoolers Language, Understanding, and Perceptions of Science and Engineering
3:45 PM-5:15 PM, Meadow Lark/Douglas Fir - 3rd floor

Children's Media as a Model of Three Dimensional Science Learning
Sara B. Sweetman, University Of Rhode Island
Kelly Jean Shea, University of Rhode Island

Educational Media's Impact on Preschool Children's Perceptions of Science and Engineering
Kelly Jean Shea, University of Rhode Island
Sara B. Sweetman, University Of Rhode Island

Divergent Paths to Building Understanding of Science and Engineering: A Comparative Case Study
Beth Rubin Holland, The University of Rhode Island
Sara B. Sweetman, University Of Rhode Island

The Effects of Media on Children's Language to Describe Scientists
Susan Trostle Brand, University of Rhode Island
Kelly Jean Shea, University of Rhode Island
Sara B. Sweetman, University Of Rhode Island

ABSTRACT
Often overshadowed by a focus on math and literacy, few studies examine the relationship between preschool children's learning and language development and their experiences with science and media. This related paper session presents four analyses as part of a broader, mixed methods intervention study funded as part of the U.S. Department of Education's Ready to Learn program. To examine the extent to which The Cat in the Hat Knows a Lot About That!™ learning ecosystem of videos, games, and hands-on activities created learning opportunities for preschool children, a university research team conducted a nine-week intervention study using a stepped wedge cluster randomized trial. The research team collected data between March-June, 2019 from 141 preschool children in 13 public preschool classrooms to measure their understanding of the nature of science and engineering, perceptions of science and engineering, and language development. The related papers presented in this session describe multiple aspects of that study: the quality of the media as a model for three dimensional science learning, the impact of the media on children's perceptions of science and engineering, the situational factors in which the intervention occurred, and the effects of the program on children's language development.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
NGSS - Practices and Implementation
3:45 PM-5:15 PM, Medford
Presider: Heesoo Ha, Seoul National University

Investigating Explicitness in Teaching the NGSS Crosscutting Concepts
Kimberly Nguyen, WestEd
Maya Salcido White, WestEd
Ashley Iveland, WestEd
Jonathan Boxerman, Northwestern University

ABSTRACT
Since the development of the NGSS, practitioners, professional development providers, and researchers alike have grappled with the idea of explicitness when providing NGSS instruction. This strategy is emphasized in the NGSS and supporting documents, which strongly underscore the need for teachers to explicitly call out and repeat concepts, content, and practices within and across contexts, grades, and disciplines. The questions around explicitness being investigated include: How might explicitness of instruction on the CCCs affect student perception of engaging in that dimension of the NGSS? How does teacher perception of incorporating the CCCs into their instruction compare with their students' perception? Data sources include teacher and student surveys, observation field notes, and pre- and post-observation interviews. Preliminary findings indicate that 1) explicitness of instruction of the CCCs did not have an observable effect on student perception of engagement in that dimension and 2) teachers' and students' perceptions of the incorporation of the CCCs in classroom instruction differed

widely. In trying to reconcile our findings and our hypothesis, we identified teacher awareness and knowledge of the purpose of the NGSS dimension as a significant factor for the discrepancy.

Middle School Science Teachers' Conceptions of Motivation Supports in NGSS Instruction
David McKinney, University of Nevada, Las Vegas
Pei Pei Liu, Michigan State University
Katy Nilsen, WestEd
Nonye M. Alozie, SRI International
Christopher J. Harris, WestEd
Lisa Linnenbrink-Garcia, Michigan State University
Gwen Marchand, University of Nevada, Las Vegas
Jennifer A. Schmidt, Michigan State University

ABSTRACT
We convened middle school science teachers (N=6) from two states for a professional learning (PL) institute as part of a larger design-based research project focused on supporting teachers’ integration of motivation in NGSS instruction. This is an exploratory qualitative study to inform the ongoing project, using surveys, artifacts, observations, and a focus group interview that captured participants’ preconceptions about student motivation in science and their emerging conceptualizations about how to support motivation through NGSS-aligned instruction. Findings indicated that teachers preconceived motivation as an individual trait of students, partly influenced by the teacher. The teachers viewed motivation in science as primarily driven by interest, perceived relevance, and the nature of tasks in science class, and identified a social dimension to motivation that science class could promote through opportunities for collaboration. During the PL, teachers began to conceptualize motivation as more malleable and something that could be planned for. The strategies teachers conceived were related to perceived relevance, supporting student autonomy with choice, and supporting competence beliefs with teacher talk. Our findings suggest the importance of explicitly targeting teachers’ enduring preconceptions and beliefs about motivation to build motivational design skills as a dimension of pedagogical content knowledge that strengthens NGSS instruction.

NGSS Instructional Practice and Impact on Student Classroom Experience: A Comparative Case Study
Maya Salcido White, WestEd
Ashley Iveland, WestEd
Katy Nilsen, WestEd
Alexis Spina, University of California, Santa Barbara
Edward D. Britton, WestEd

ABSTRACT
The NGSS have addressed equity in science education by creating standards and practices that support teachers to connect science learning to their students’ lives. In this study, we drew on literature about students’ funds of knowledge, sense of place, and reform-oriented teacher practices to examine the enactment of two middle school teachers implementing NGSS. We asked: How do teachers’ pedagogical beliefs influence their equity-focused instructional practices when implementing the NGSS? How did teachers’ enactments impact students’ experiences in the classroom? Data were collected from student surveys, classroom observations, and teacher interviews. We found stark differences in instructional practices for the two focal teachers, with one teacher demonstrating a reform-oriented approach and the other a traditional approach. Descriptive statistics from survey results indicated that students in the reform-oriented classroom reported learning about topics relevant to their community and personal life

at higher rates than students in the traditional classroom. However, students in the traditional classroom agreed at higher rates that topics covered in science class had significance to themselves and their community. The scope of the current work will be expanded to include teacher and student data from our larger investigation of middle school teacher's enactment of the NGSS.

Teachers' Understanding and Implementation of Equitable Instructional Strategies with the NGSS

Alexis Spina, University of California, Santa Barbara
Meghan Macias, University of California, Santa Barbara
Ashley Iveland, WestEd
Ted Britton, WestEd

ABSTRACT

With classrooms in the U.S. becoming increasingly linguistically and culturally diverse, concerted attention must be paid to understanding how best to serve all students. The Next Generation Science Standards (NGSS) are designed to provide equitable science learning for all students. However, many science teachers will need to make instructional shifts to implement strategies that reach all learners. In this study, we examined how science teachers from various middle schools in California implemented strategies intended to reach all learners. Data sources were interviews with and one observation of 24 teachers, and a survey of their students. We also compared teachers' description of their teaching to what their students reported as their classroom experience. Most science teachers reported using strategies that involved drawing on their students' funds of knowledge, as well as providing a space for students to initiate questions and investigations. Student responses on most survey questions were congruent with what the teachers said. However, over half of the students reported that their teacher initiated any questions or investigations, in contrast to teachers' comments that investigations more frequently were based on student interests.

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

Diverse student perceptions, positioning, and retention in STEM

3:45 PM-5:15 PM, Salon D

Presider: Melo-Jean Yap, San Diego State University

"Makes me think more": Student Perceptions of Learning in a Student-Centered Classroom

Ashley N. Harlow, University of California, Irvine
Brian Sato, University Of California, Irvine

ABSTRACT

Currently, underrepresented minority (URM) students are leaving STEM programs at high rates. Previous research has shown that student-centered instructional strategies have positively impacted the academic achievements of URM students differentially from their more traditional peers. However, little research has focused on digging deeper to understand the student perspective of such instructional strategies. Using an asset-based framework, we sought to understand the URM student perspective on student-centered classrooms. Through interviewing 11 URM students in a student-centered biological sciences course, we have found that students perceived learning in traditional and student-centered classrooms differently and found instructor lesson planning to be vital for a successful course. Latinx students reported peer engagement was beneficial for their learning to be comfortable communicating ideas in the course and asking peers questions as well as building relationships with those from the same culture as themselves. This common occurrence for Latinx students supports Yosso's community

of cultural wealth framework that URM students have unique strengths that can contribute to their success if given the opportunity to utilize them. Specifically, we have found evidence of the use of linguistic and social capital from Latinx students. This work has implications that student-centered learning is beneficial for URM student success

Educational debts in students' physics beliefs incurred by racism and sexism

Jayson M. Nissen, California State University, Chico
Ian Her Many Horses, University of Colorado Boulder
Ben Van Dusen, California State University Chico

ABSTRACT
Physicists hold a distinct set of beliefs about what it means to learn and do physics. Evidence shows that physics education does not support students in developing these beliefs. Instead, degree programs filter out students without sufficient beliefs. We investigated the intersectional nature of race/racism and gender/sexism in inequities in student beliefs towards learning and doing physics using a critical quantitative intersectionality framework. The data came from the Colorado learning attitudes about science survey and included 1248 students in 29 calculus-based mechanics courses. Like prior studies, we found only small changes in beliefs that tended toward less expert-like beliefs for most groups. Results identified large differences across race and gender groups that advantaged White men. Physics instruction must address these educational debts to move toward an inclusive culture supportive of diverse students and professionals.

Impact of PBL chemistry laboratory curriculum on persistence of traditionally at-risk students majoring in engineering

Corey A. Payne, University Of Florida
Kent J. Crippen, University of Florida
Lorelie Imperial, University of Florida

ABSTRACT
This field study of a problem based laboratory curriculum, examined changes in engineering self-efficacy, engineering identity, and career commitment across one semester for two groups of students taking general chemistry laboratory for engineers, comparing it with a more typical, business-as-usual laboratory curriculum. A one-way MANOVA and with to determine differences in outcomes for Career Commitment, Engineering Self-Efficacy, Teamwork Self-Efficacy and Engineering Identity between the two curricula disaggregated by gender and ethnicity. Peason's correlation coefficients were then calculated for each variable. This calculation was repeated on multiple subgroupings of the participants in order to compare how closely the model fits the targeted populations, namely, women and underrepresented minorities.The results suggest that in general, and for our female identifying students specifically, participants enrolled in the PBL course are achieving the same level of success in the measured variables as their peers in the BAU course. This study shows that Engineering Identity is a key variable in predicting Commitment to and Engineering career across our target populations and that our PBL curriculum shows the same positive effects as the BAU curriculum while increasing difficulty, creative problem solving and alignment with the practice of engineering.

Institutional context and identity of Black undergraduates pursuing STEM degrees

Eileen Carlton Parsons, University Of North Carolina At Chapel Hill

ABSTRACT
Research has documented the influence of social identifiers like race in the pursuit and attainment of STEM and related careers for various demographic groups. Even though the 40% increase of Blacks intending to major in STEM in recent years indicate progress (National Science Board, 2018), Blacks continue to trail their counterparts and fare below their 13% representation in the population in degree conferrals. Degree attainment for Blacks in science and engineering is approximately 9% and 4%, respectively, with declines in mathematics in recent years (National Science Foundation, 2019). Some universities and colleges have acted to address the underrepresentation of Blacks in STEM and the challenges Blacks face in STEM. Many initiatives target factors internal to individuals while others prioritize contextual factors external to individuals; yet, some programs attempt to address the intersections among internal and external factors. Efforts at the intersections of internal and external factors sometimes center identity development with respect to STEM. The primary objective of this work is to examine institutional context where internal and external factors intersect in identity development with respect to STEM, specifically for Black students majoring in STEM at a Predominately White Institution (PWI) and a Historically Black College and University (HBCU).

Strand 6: Science Learning in Informal Contexts

Science learning in museums and zoos

3:45 PM-5:15 PM, Salons E & F

Presider: Reanna S. Roby, Michigan State University

Designing Complementary Activities for Learning in Classrooms and Fieldtrips to an Interactive Science Center

Danielle Boyd Harlow, University Of California At Santa Barbara
Ron Skinner, Ron.Skinner@moxi.org
Alexandria Muller, University of California- Santa Barbara

ABSTRACT
Partnerships between schools and other institutions can create new opportunites for learning that leverage the affordances of multiple types of institutions. For example, informal science institutions, such as science museums provide rich learning opportunities for youth that can complement school learning. However, how to effectively design materials for these different type of institutions that are mutually beneficial is not well understood. We explore how to effectively design modules of activities that leverage the unique affordances schools and an interactive science museum to result in students learning science through the practices of science and engineering during a field trip program and in pre and post activities completed in elementary school classrooms. This work presented here part of a larger project which follows a design-based implementation research (DBIR) model and is conducted through a long term Research-Practice Partnership (RPP) between a research university and an interactive science center. Six design principals for developing complementary school and field trip activities are presented based on iterative development and testing the field trips and activities with 18 classrooms ranging from grades 1 through 6 and representing a range of demographics.

How students interact with a model scale in a science museum lab activity?

Orit Ben Zvi Assaraf, Ben-Gurion University Of the Negev, Israel
Neta Shaby, Ben-Gurion University of the Negev, Israel
Nicole Pillemer, Ben-Gurion University of the Negev, Israel

ABSTRACT
There are relatively few studies examining school laboratory and cooperative learning approach. Furthermore, this kind of research in the museum lab setting is rare. This study aims to explore science museum lab activity, study the components of the interaction to better understand the nature of cooperative learning, if any, in that setting. The participants in this study were 59 fourth grade students, visiting a science museum lab activity, as part of a school field trip. The students, divided into 12 groups, were videotaped and audio recorder during group activity of balancing a model scale. We analyzed our observations using an inductive data analysis approach. Our study can add to the body of knowledge examining both school visits to informal settings and the nature of collaborative learning in a science lab. Our research of the interactions among peers during the activity in the laboratory divides, as expected, to four core categories— physical, social, emotional and cognitive, with the cognitive domain produced fewer interactions than the others. However, when examining the different interactions characteristic of the groups, none of the groups were similar. Every group interaction hallmark was unique, and the distribution of the categories was typically different in each group.

Study of Influence the Museum Model on High School Students' Chemistry Learning

Ana Carolina Steola,
Franciani Cássia Sentanin,
Patrícia Silva,
Ana Cláudia C. Kasseboehmer, University of São Paulo

ABSTRACT
This paper presents the results of a study with high school students from a public school located located in the interior of São Paulo-SP. The chosen subject was oxirreduction. An museal interactive chemistry model was used, which shows the degradation of dyes present in the water due to the disposal of the textile industry through oxidative processes, and an experiment that demonstrates the corrosion of metals. The chemistry teacher introduced the concept in a lecture and later was made a visit of students to the Museum of Science, where is the model, and where the experiment was also performed. The introductory class, the model visit and the experiment took place in order to obey a previously established conceptual organization, favoring the processes of progressive differentiation and integrative reconciliation based on Ausubel's theory of learning. Tests were applied in the introductory class, after the visit to the model and also after the experiment for subsequent comparison of results, which were used to verify if the use of the model and the experiment promoted significant learning in relation to the proposed theme.

Development of Environmental Science Agency in Youth Participating in Natural History Museum-Led Citizen Science Programs

Maryam Ghadiri Khanaposhtani, UC Davis
Heidi Ballard, University Of California Davis
Julia Lorke, Natural History Museum
Lucy Robinson, Natural History Museum
Jessie Jennewein, Natural History Museum of Los Angeles County
Annie E. Miller, California Academy of Sciences
Sasha Pratt-Taweh, The Natural History Museum
Lila Higgins, Natural History Museum of Los Angeles County
Rebecca Johnson, California Academy of Sciences
Alison Young, California Academy of Sciences

ABSTRACT
In a research-practitioner partnership, we study youth participation in Community and Citizen Science (CCS) programs led by three Natural History Museums (NHM) in the US and the UK. We analyzed the features of the learning settings in long-term projects that foster or hinder youth participation and science learning, specifically contribution to the development of expertise, identity, and agency in environmental science, here termed Environmental Science Agency (ESA). We qualitatively analyzed observations, interviews and surveys. Our findings revealed youth participation was mainly focused on the process of exploration (e.g. searching for wildlife) and observation, and occasionally data collection. We found that access and guidance to scientific tools opened up opportunities for learning by supporting youth to take on meaningful roles around wildlife observation, species identification and documentation. However, limited opportunities for recording their observations and submit them as data, to become a valid biological record, seemed to minimize the possibility for youth agency with science. We suggest creating opportunities for youth to connect their experiences and roles to scientific research and identify themselves as part of citizen science, and understand how their actions matter and contribute to scientific research help to the development of identity and agency with science.

Strand 6: Science Learning in Informal Contexts
Storybooks and STEM: Using Books as a Tool to Support Early Childhood Family STEM Learning

3:45 PM-5:15 PM, Salon C
Discussant: Phyllis Katz, University of Maryland
Presider: Scott A. Pattison, TERC

National Survey Results on the Use of Children's Books to Support STEM Learning
Scott A. Pattison, TERC
Gina Svarovsky, University of Notre Dame
Phyllis Katz, University of Maryland

A Cross-Storybook Analysis of How Story-Driven Investigations Engage Preschool-Age Children in Science Practices
Julia Plummer, Pennsylvania State University
Kyungjin Cho, Pennsylvania State University

Impacts of Connecting Children's Storybooks and Science to Increase Educator Knowledge, Confidence, and Skills Leading STEM Programs
Tara Cox, The Franklin Institute
Julia B. Skolnik, The Franklin Institute
Karen Peterson, National Girls Collaborative Project
Erin Stafford, Education Development Center
Sara Greller, Education Development Center

ABSTRACT
Children’s storybooks are a ubiquitous learning resource, and one with huge potential to support STEM learning. They also continue to be a primary way that children learn about the world and engage in conversations with family members, even as the use of other media and technology increases. Especially before children learn to read, storybooks create the context for in-depth learning conversations with parents and other adults, which are the central drivers of STEM learning and development more broadly

at this age. Although there is a body of literature highlighting the benefits of storybooks for children's learning in classrooms and clinal laboratory settings, less work has been done to understand their potential for informal STEM learning contexts. This session will share findings from recent studies exploring the use of storybooks with preschool-age children (3 to 5 years) and their families in these settings, including afterschool programs, museums and science centers, and home-based family programs. The session will begin with results from a national survey of researchers and educators using children's books to support STEM engagement and learning in early childhood, followed by findings from three specific projects exploring this topic.

Strand 7: Pre-service Science Teacher Education

Practice-based Science Teaching

3:45 PM-5:15 PM, Salon A

Presider: Jacqueline N. Ekeoba, University of Houston

Hybridizing Equity-focused, Field-Based Theory and Practice for Pre-service Science Teachers

Alexandra I. Race, UC Santa Cruz
Doris B. Ash, University Of California - Santa Cruz

ABSTRACT

In this study, we examine three main areas of contradiction centering on what hybridizing equity-based with field-based learning actually entails in terms of practices and beliefs for secondary science preservice teachers (PSTs) participating in a year-long professional development program. Such research calls upon, at times, contradictory areas of scholarship, which have arisen from different theoretical and epistemological foundations. We refer to first, equity-based and, second, field-based, and their differing historical and epistemological roots. We use cultural historical activity theory (CHAT) (Engestrom, 1987) to explore the dialectical relationship between individual agentic vs. structural forces. As is typical with CHAT we focus on contradictions (tensions) in activity systems as the levers for transformation (Engestrom, 1987; Foot, 2014). Dialectical relationship are very much part of CHAT (Cole, 1998) as they are the essence of the structure/agency relationship (Gutiérrez & Calabrese Barton, 2015). Using three levels of analysis, the larger program, the cooperating teacher/pre-service teachers dyads, and individual PSTs, we trace several possible contradictions and dialectical relationships between understandings of equity and field-based learning and their possible 'hybrid' forms. Three reported here include: (1) Negotiating the meaning of equity; (2) Situating resources as mediational means; and (3) A grit/bootstrap stance.

Practice-based Approaches to Elementary Science Teacher Preparation: Examination of an Immersed Methods Course Model

Stephen L. Thompson, University of South Carolina

ABSTRACT

The research reported here examined the impact that guided, practice-based approaches to science teaching utilized within an elementary science methods course had on preservice teachers' (n=138) science teaching self-efficacy. In this study practice-based instructional approaches are defined as engaging preservice teachers with teaching approximations that occur in authentic classroom settings with students and center on teaching practices such as formative assessment and crafting responsive instruction using supportive curriculum materials. The research also examined which practice-based features were most likely to influence preservice teachers' science teaching self-efficacy. Results indicate positive changes across areas associated with science teaching self-efficacy. Additionally, analysis revealed that preservice teachers viewed guided "practice teaching experiences" as being most impactful on their beliefs about science teaching and their self-perceptions as science teachers. Opportunities to engage in collaborative formative assessment of students and associated responsive teaching were especially impactful. Preservice teachers frequently referenced the value in making conections between theories learned within methods courses and strategies enacted in elementary classrooms.

How Do Secondary Science Teacher Candidates' Noticing Skills Develop in the Context of their Methods Courses?

Rebecca McNall Krall, University of Kentucky
Brett A. Criswell, West Chester University of Pennsylvania
Samantha Ringl, University of Kentucky

ABSTRACT

Noticing student thinking is an essential skill for science teachers to facilitate student-directed investigations and meaning-making discussions. Drawing from research on developing teacher candidates' abilities to notice students' thinking, this case study sought to explore the development of four secondary science teacher candidates' noticing skills as they progress through two consecutive methods courses where video cases were used to develop their noticing skills and their knowledge of effective pedagogical practices. Data consisted of candidates' written responses to noticing activities, video and audiotape recordings of class discussions about each video case, and field notes of class observations and periodic meetings with the instructor. Qualitative methods were applied to identify changes in candidates' noticing skills and to identify instructional components that supported or hindered their skill development. Findings revealed a gradual increase in candidates' noticing skills across the two method courses and an increase in the sophistication and framing of the events to which they attended. The video analysis template provided a scaffold to guide candidates' observations and written responses, whereas selection of science video clips outside candidates' areas of expertise proved to hinder their abilities to attend to and interpret students' ideas in those areas.

Activity Theory and Identity: A Framework for Investigating Teacher Research Experiences and Classroom Practices

Daniel L. Moreno, University of Arizona
Austin R. Cruz, University of Arizona
Sanlyn Buxner, University Of Arizona
John M. Keller, University of Colorado - Boulder
Lawrence Horvath, San Francisco State University
Deidre B. Sessoms, California State University, Sacramento
Dermott Donnelly-Hermosillo, California State University, Fresno
Elsa K. Bailey, San Francisco State University
Bo Zhu, American Institutes for Research

ABSTRACT

Research experiences are becoming popular as a means of teacher preparation but little is known about their long-term relationship to teachers' classroom practices, retention, persistence, leadership, and student achievement. Limited data on these experiences are often self-reported and much of the research lacks strong theoretical foundations. This study addressed these gaps using a novel methodology to triangulate teachers' accounts with those of their supervisors and students and

theoretical framework, which synthesized activity theory (Engeström, 2015) and identity negotiated through communities of practice (Wenger, 1998). This framework illuminated the relationship of multiple activity systems, or communities of practice, to both the direct objects of the individual systems and their shared object, in this case the teachers' identities. We investigated whether enhancing teachers' identities as researchers through a formalized research experience for teachers program might lead to observably distinct classroom practices from teachers who had not participated in such a program. Preliminary analysis of the teacher interview data revealed that research experiences do mediate a researcher identity in program participants and influence classroom practices along three distinct themes: the implementation of inquiry labs, modeling of a researcher mindset, and the contextualization and validation of classroom practices in the real world.

Strand 8: In-service Science Teacher Education

Scaling an Effective Analysis-of-Practice PD Program in Two High-Needs Districts: Impacts, Successes, and Challenges

3:45 PM-5:15 PM, Salon B

Discussant: Gillian H. Roehrig, University of Minnesota

Presider: Kathleen J. Roth, California State Polytechnic University, Pomona

Developing Elementary Analysis-of-Practice PD Teacher Leaders in an Urban District: Teacher and Student Impact

Paul M. Beardsley, California State Polytechnic University, Pomona
Joseph A. Taylor, University of Colorado, Colorado Springs
Kathleen J. Roth, California State Polytechnic University, Pomona
Rebecca Eddy, Cobblestone Applied Research & Evaluation, Inc.
Nicole Wickler, California State Polytechnic University, Pomona
Christopher Wilson, BSCS Science Learning
Stacey L. Carpenter, University of California - Santa Barbara

Factors that Support and Challenge Scaling of Videobased Analysis-of-Practice PD through K-6 Teacher Leader Development

Nicole Wickler, California State Polytechnic University, Pomona
Rebecca Eddy, Cobblestone Applied Research & Evaluation, Inc.
Kathleen J. Roth, California State Polytechnic University, Pomona
Stephanie Baker, Pomona Unified School District

A Video-Based, Analysis-of-Practice PD Program in High School Biology: Results for Students, Teachers, and TLs

Jody Bintz, BSCS Science Learning
Connie Hvidsten, BSCS Science Learning
Christopher Wilson, BSCS Science Learning
Molly Stuhlsatz, BSCS Science Learning
April L. Gardner, BSCS Science Learning
Cynthia Gay, BSCS Science Learning

Factors in Scaling a Videobased, Analysis-of-Practice PD Program through Development of High School Biology TLs

Christopher Wilson, BSCS Science Learning
Jody Bintz, BSCS Science Learning
Connie Hvidsten, BSCS Science Learning
Molly Stuhlsatz, BSCS Science Learning
April L. Gardner, BSCS Science Learning
Cynthia Gay, BSCS Science Learning
Gillian H. Roehrig, University of Minnesota

ABSTRACT
This paper set reports results, successes, and challenges from two efforts to scale up the effective, rigorously-researched Lesson Analysis for Science Teachers (LAST) professional development (PD) program to extend its reach throughout large, urban school districts. The previously-demonstrated impact of LAST on teacher and student learning was significant with large effect sizes, but the program depends on knowledgeable, skilled PD leaders working with small teacher study groups for a year. Can LAST be adapted to reach the large numbers of teachers in high-needs, urban districts who can benefit? Two different research teams partnered with large, urban districts (in Western and Midwestern states) to tackle this issue by exploring whether the LAST approach could be effectively scaled through the development of district-based teacher PD leaders. In the session, each project (one focused on grades K-6, one on high school biology) will present two papers, one that describes the scaling effort and reports learning results for teacher leaders, teachers, and students; and one that describes factors that enabled or obstructed successful scaling. A district partner from each project will comment on challenges and lessons learned. The discussant will compare and contrast the two efforts and consider implications and broader impact.

Strand 8: In-service Science Teacher Education
Student Achievement
3:45 PM-5:15 PM, Pearl
Presider: Darrin Collins

Effects of Professional Development and Classroom Learning Environment on Student Science Achievement

Siqi Li, State University Of New York At Buffalo (SUNY)
Xiufeng Liu, State University Of New York At Buffalo (SUNY)

ABSTRACT
Using the Program for International Student Assessment (PISA) 2015 data, this study aims to explore the multi-level relationships between student reported classroom learning environment (CLE), school-level teacher professional development (PD), and the possible interaction effects between the two on student science achievement. Since sample students were nested within schools, two-level hierarchical linear models (HLM) was conducted to analyze the data. The study results indicate science CLE factors include adaption of instruction, disciplinary climate had significant positive relationships with student science achievement, while inquiry-based science teaching and learning practice and perceived feedback had significant negative relationships with student science achievement. For school-level PD factors, proportion of PD in school science and proportion of teacher attend PD activity within 12 months had significant positive relationship with student average science achievement between schools. Most

importantly, significant cross-level interaction effect was found between requirement of PD and disciplinary climate. Explicit suggestions were made on how to create science CLE that promote student science learning, how science teacher PD should be conducted through the perspective of school level, and how PD should be required differently in terms of varies CLE, such as disciplinary climate.

Out-of-Field Physics Teaching in Urban, Suburban, and Rural Contexts

Robert Krakehl, Stony Brook University
Angela M. Kelly, Stony Brook University
Keith Sheppard, Stony Brook University
Linda Padwa, Stony Brook University

ABSTRACT

This observational study focused on the content preparation of physics teachers in an analysis of certification level (primary vs. secondary), in addition to in-field vs. out-of-field certification status. The sample included public-school physics teachers (n=1387) in New York State in the academic year 2011-12. Data were collected from a variety of publicly available sources including the teachers' primary and secondary certifications, courses they taught, the locales and socioeconomic status of their schools and the teachers student performance on physics standardized exams. Findings indicated that overall the number of teachers teaching physics out-of-certification was relatively low, but masked large disparities when considering locale and socioeconomic status, with suburban and rural schools having very few out-of-field teachers, while in urban and high need schools they were much more prevalent. Multivariable regression analyses indicated students of out-of-field physics teachers did not perform as well as students of certified teachers, however, student performance was not related to whether or not teachers had primary certification (the equivalent of a degree) or secondary certification (minimum number of credits) in their field. In both cases, school-level socioeconomic status was the main predictor of student performance. Implications related to equity considerations and science teacher certification policy are discussed.

School Counseling and the Preparation of Pre-College Students for STEM Careers

Richard Gearns, Stony Brook University
Angela M. Kelly, Stony Brook University
Monica Bugallo, Stony Brook University

ABSTRACT

This pilot, ongoing research explored how school counselors prepared to offer advisement for science and engineering career preparation and in what ways and to what extent do school counselors interact with students to impact pre-college preparation for post-secondary engineering study and careers. The study employed a qualitative, phenomenological approach using a semi-structured interview protocol. Data were collected from school counselors in middle and high schools to gain understanding of current counseling practices and to see how university-based training might improve their knowledge to impact student participation and preparation for STEM in higher education. Study participants represented both high and low needs urban and suburban schools. The study found that counseling practices vary widely with respect to career planning with early planning occurring more often in high needs schools. Student ability tracking keeps some students from taking upper level science and mathematics courses. Counselor gatekeeping continues to affect student entry into STEM due to an inability to provide appropriate and timely information to potential STEM candidates. School structure, including counselor workload, poor collaborative relationships, and a lack of robust feedback loops make it difficult to schools and counselors to adapt to changes in the STEM landscape.

Strand 10: Curriculum, Evaluation, and Assessment

Assessing scientific concepts across disciplines

3:45 PM-5:15 PM, Columbia

Presider: Peng He, Michigan State University

Systems Thinking Theory and Practice in Chemistry Education ---Three international case studies

Mei-Hung Chiu, National Taiwan Normal University
Rachel Mamlok-Naaman, The Weizmann Institute of Science
Jan Apotheker, Faculty of Science and Engineering University of Groningen, The Netherlands

ABSTRACT

Linking school science content knowledge with daily life experiences has been discussed for decades. However, students are still lacking of competence of constructing interconnection of content knowledge and using them for problem solving on environmental issues. This presentation is to propose an emerging need of a learning/teaching tool, Systems Thinking (ST), that has been suggested as a framework of though, based on holistic understanding of complex systems, to aid in dealing with the systems and their problems. With such approach, we believe it could provide students opportunity to emphasize their learning not only on individual subject contents but also outside of disciplinary specializations. Three examples on context-based science instruction and assessments were drawn to pinpoint the problems and challenges of chemistry education from Israel, the Netherlands, and Taiwan. We advocated ST should be embedded in instructional materials as well as formative or summative assessment of students' learning outcomes.

Measuring interdisciplinary application of the energy conservation principle: A physics/chemistry instrument pair

Emily J. Borda, Western Washington University
Todd Haskell, Western Washington University
Andrew Boudreaux, Western Washington University

ABSTRACT

We have created a unique instrument pair to measure the extent to which individuals have learned and can apply a foundational science concept, the Law of Conservation of Energy (LCE), to a new context. The Energy Reasoning in Physics (ERP) assessment measures original learning of LCE in a physics context, while the Energy Application in Chemistry (EAC) assessment measures an individual's ability to apply this knowledge in chemistry. A concept integration index uses scores on these two measures to express the extent to which students can apply their original learning in a new context. This instrument pair has been given to students in a coherent science course series for preservice elementary teachers built around the central theme of flow of matter and energy, as well as to other students representing a range of experience with college science. Significant correlation of scores between the two instruments suggest they measure similar content. Average scores increase with greater numbers of college science courses taken. We discuss evidence of validity of these two instruments and propose uses in various contexts.

Learning Progressions in Science Assessments

Karyn Housh, Indiana University
Abeera P. Rehmat, Purdue University
Cindy E. Hmelo-Silver, Center for Research on Learning & Technology
Dante Cisterna, Educational Testing Service
Lei Liu, Educational Testing Service

ABSTRACT
For this research study we construct hypothetical, but theoretically grounded learning progressions (LPs) for two cross-cutting concepts (CCCs), Structure and Function (S-F) and System and System Models (S-SM). Working with experts in the field, and guided by the current science standards, we hypothesise that these LPs would provide a descriptive map of novice to expert level understanding of the two CCC's. These LPs form the basis for the development of three assessments which we embed in simulations within the specific science domains of ecosystems, earth systems and body systems. For this study, just over 200 students participate from grades six, eight and nine from a Midwestern school district. Student responses are mapped unto the LPs and the results analysed to validate these hypothesised learning progressions. The use of LPs as demonstrated in this study, offers educators and researchers the opportunity to utilize qualitative guidelines (LPs), to better discern where student understanding and misconceptions may lie in the study of S-F and S-SM.

Developing an Integrated Learning Progression and Assessments to Measure Middle School Student Proficiency of Energy

Peng He, Michigan State University
Namsoo Shin, Michigan State University
Tingting Li, Michigan State University
Joseph S. Krajcik, Michigan State University

ABSTRACT
Assessing and tracking student science proficiency of energy across time are essential for providing feedback continuously and coherently on their making sense of real-life phenomena. This study developed an Integrated Learning Progression (ILP) and associated classroom-based assessments integrating Disciplinary Core Ideas, Scientific and Engineering Practices and Crosscutting Concepts to map out middle school student science proficiency in energy. Using the multiple components of validity, an iterative review process at each design stage was conducted and analyzed as the cognitive validity of the ILP and associated assessments. The multiple components of validity (cognitive, instructional and inferential) for the ILP and assessments will be presented in the full paper.

Strand 10: Curriculum, Evaluation, and Assessment
Automated Scoring of Complex Performances

3:45 PM-5:15 PM, Salmon

Discussant: James Pellegrino, University of Illinois at Chicago
Presider: Charles W. Anderson, Michigan State University

Automated Scoring of Complex Performances

Charles W. Anderson, Michigan State University
Xiaoming Zhai, Michigan State University
Karen Draney, University of California, Berkeley

Jay Thomas, Act Inc.
Karen D Wang,
Jill A. Wertheim, Stanford University
Brian W. Riordan, ETS
James Pellegrino, University of Illinois at Chicago

ABSTRACT
This symposium focuses on the development of automated scoring systems for complex performances associated with science teaching and learning, including three-dimensional science performances, problem solving, and video-based assessments of teachers' pedagogical content knowledge. The contributors to this session include representatives of the United States' two largest educational testing organizations, a leading assessment center, a leading science education research and development center, and major research universities. Each presenter addresses automated scoring systems in the context of a development process that involves each corner of the NRC assessment triangle: Interpretation, Cognition, and Observation. With respect to Interpretation, presenters discuss approaches to issues of reliability, validity, and fairness in the development of automated scoring algorithms. With respect to Cognition, presenters discuss how automated scoring systems are based on theories of learning and performance—especially complex performances involving three-dimensional scientific reasoning. With respect to Observation, presenters address issues of task design and observation protocols that produce machine-scorable records of complex performances. Discussion will focus on the role that automated scoring can play in an iterative development process involving all three corners of the triangle, leading toward improved assessment systems for research and large-scale assessment.

Strand 11: Cultural, Social, and Gender Issues
Considerations for Girls & Women in Science and Engineering
3:45 PM-5:15 PM, Salon H
Presider: Melody Russell, Auburn University

Examining the effect of counterspaces on undergraduate women in physics
Zahra Hazari, Florida International University
Idaykis Rodriguez, Florida International University
Eric Brewe, Drexel University
Renee-Michelle Goertzen, American Physical Society
Theodore Hodapp, American Physical Society
Monica Plisch, American Physical Society

ABSTRACT
For students from underrepresented groups who face marginalization in a discipline, counterspaces are safe spaces of refuge that allow them to express their multiple identities and fortify their sense of belonging. In physics, two potential counterspaces for undergraduate women are the Conferences for Undergraduate Women in Physics (CUWiP) and Women in Physics Groups (WiPG). Drawing on survey data collected from undergraduate women in physics who were registering for the 2018 CUWiP, we used Structural Equation Modeling (SEM) to test the effect of earlier participation in CUWiP and WiPG on students' current sense of belonging and interest in physics. We also tested the mediating effect of believing that there are gender issues in physics since many young women are unaware of gender bias in physics. The results revealed a significant positive direct effect of CUWiP and WiPG on sense of

belonging. A more complex story emerged for indirect effects where believing that there are gender issues can positively or negatively affect sense of belonging depending on whether interest is reinforced. The findings indicate that CUWiP and WiPG act as counterspaces. Activities in these spaces where students learn about gender bias, however, should also work to fortify students' interest.

Girls Constructing Engineering Identities through STEM Design Challenges

Christina L. Baze, University of Texas at Austin
Todd L. Hutner, The University of Alabama
Victor D. Sampson, University Of Texas At Austin
María González-Howard, University Of Texas At Austin
Catherine Riegle-Crumb, University of Texas at Austin
Richard H Crawford, The University of Texas at Austin

ABSTRACT

Documents such as The Next Generation Science Standards (NGSS Lead States, 2013) and Changing the Conversation (National Academy of Engineering, 2008) attempt to increase participation in engineering in K-12 education, especially for girls and other underrepresented groups. One line of research important to this goal is engineering identity construction. The purpose of this study is to understand middle school girls' experiences with STEM design challenges (SDCs) and how these experiences influence the development of engineering identities. This study utilizes a sequential explanatory mixed methods design (Creswell, 2014). First, a mixed-design repeated measures analysis of variance (ANOVA) method was employed to test the effects of time (participation in SDCs) and gender on engineering identity. Later, focus groups were conducted to explain how the essential experiences of boys and girls doing SDCs may influence identity construction differently. For all three identity measures - recognition, interest, and competence (Godwin, 2016) - gender was the only significant effect, with girls consistently reporting lower measures of engineering identity. Our study uniquely focuses on identity construction in formal engineering education and includes students that went down in identity measures, exposing factors that not only contribute to increased identity, but those that contribute to decreased identity.

Identity Work of Successful Women in Science During Their School Years

Jonathan L. Hall, University of West Florida
Malcolm B. Butler, University of Central Florida

ABSTRACT

Science educators have the opportunity to inspire students to accomplish goals that may seem impossible. For many girls, developing a positive science identity can be a challenging process. During their school years, they navigate several contexts and environments which are often detrimental to their science identity development. This is an ongoing problem that science teacher educators should address and disrupt. Understanding the experiences of successful women in science during their school years offers insight into addressing this issue. The conceptual framework consisted of the following three constructs: identity work, positioning, and agency. This qualitative phenomenological study describes the school year experiences of 12 women who were successful in science. With each participant, three interviews were facilitated that each required roughly two hours. The data were analyzed by a 6-step process that led to four emergent findings. First, participants consistently positioned themselves as having a passion for science from an early age. Second, they were persistent through challenges often based on gender biases that they experienced in science contexts. Third, their passion for science led them to engage in informal science experiences. Fourth, these experiences helped them to take on leadership roles in academic groups.

Seeing Women's Science and Engineering Experiences: The Affordance of a Visual Methodology in Understanding Context

Helen Douglass, University of Tulsa
Geeta Verma, University of Colorado Denver
Bryan Shao-Chang Wee, University of Colorado Denver

ABSTRACT
In this paper, we share the affordance of the use of a visual methodology, specifically photo-elicitation, to make women's STEM experiences (education and career) visible and to create context about important events in their lives related to their STEM experiences. Adopting a visual methodology where participants share their experiences via images and captions can increae our understanding and go deeper into the contexts women are coming from related to their science and STEM pursuits. The purpose of the study was to enable women to articulate their contexts about their STEM experiences in remaining in or leaving thier physics or engineering careeers. Useing photo-elicitation allowed data to emerge and its analyses helped create a framework called Contextual Critical Junctures that allowed for the inclusion of context related to the experiences and a way of integrating many different experiences across categories and ages. By asking participants to look back and reflect on their experienes and share images related to those experiences, we can continue looking forward for ways to provide experiences and contexts that are meaningful for girls and women in their STEM endeavors. Key words: Visual methodology, STEM experiences, contexts, gender equity, formal and informal settings

Strand 12: Educational Technology
Breakthroughs in Online Learning
3:45 PM-5:15 PM, Salon G

Building Community in an Online Asynchronous PD Course: Designing for Social Capital Development

Katherine Miller, University of Pennsylvania
Susan Yoon, University of Pennsylvania
Denise M. Bressler, University of Pennsylvania
Daniel Wendel, Massachusetts Institute of Technology
Ilana Schoenfeld, Massachusetts Institute of Technology
Emma Anderson, Massachusetts Institute of Technology

ABSTRACT
This research investigates a design and development approach to improving science teachers' access to high-quality PD toward enacting a scalable model of delivery. Working with a small number of teachers, this proof-of-concept exploratory study details how we combined social capital mechanisms with essential teacher learning and PD requirements to overcome existing challenges in the delivery of a PD course on a fully online asynchronous platform. Findings reveal comparably high satisfaction and usability of course materials as compared to previous face-to-face PD with similar content. Teachers also articulated positive experiences as a result of the intentional social capital course design in the areas of tie quality, depth of interaction, and access to expertise. However, the development of trust among teachers was harder to construct. Implications for this work for asynchronous online PD approaches at larger scales are discussed.

Modeling with Real-Time Informative Feedback: Implementation and Assessment of a New MOOC Component

Niva Wengrowicz, Technion - Israeli Institute Of Technology Levinsky College - Research & Development Authority MOFET Institute - School of Professional Development
Rea Lavi, Technion- Israeli Institute Of Technology
Daniel Gluskin, Technion - Israel Institute of Technology
Uri Shani, Technion - Israel Institute of Technology
Hanan Kohen, Technion - Israel Institute of Technology
Dov Dori, Technion - Israel Institute of Technology

ABSTRACT

As we designed, developed, and deployed a MOOC on Model-Based Systems Engineering, we introduced MORTIF—Modeling with Real-Time Informative Feedback, a new learning by doing feature, which enables the learner to model, receive detailed feedback, and resubmit improved solutions. We examined the extent to which MORTIF is an effective active learning component by investigating characteristics of participants working with MORTIF, their perceived contribution of this component, preferred problem type, and learning style. The research included 63 participants and applied the mixed method, using server data and online questionnaires. Analyzing 2583 submissions, we found increasingly frequent use of the model resubmitting option. Students perceived the contribution level of MORTIF-type problems as high and preferred them over others. We identified and classified nine learning style categories. We found high effectiveness of the embedded MORTIF-type problems as promoters of meaningful learning, confirming our assumption that the combination of active learning with real-time informative feedback is an excellent mode of learning that students embrace and benefit from. Benefits of MORTIF include active learning, provision of meaningful immediate feedback to the learner, the option to use the feedback on the spot and resubmit the improved model, and its suitability for a variety of learning styles.

Online ethics education: expectations, views, and the design components that may foster ethical practices

Miri I. Barak, Technion - Israel Institute Of Technology

ABSTRACT

Higher education institutions require science and engineering graduate students to study online courses on ethics of research. Recent studies show that conventional online RCR training programs that encompass individual learning and machine-graded exams do not produce meaningful educational experiences. Hence, the goal of the current study was to examine novice researchers' expectations and views regarding online ethics education, and to identify the instructional design components that may foster ethical practices. Applying the mixed methods approach, data were collected via a survey and semi-structured interviews among MSc and PhD students in science and engineering. The findings reinforce the need to provide novice researchers with tools that will help them build self-confidence in online learning; provide active and interactive learning assignments to narrow the gap between ethical knowledge, awareness, and practice; and offer personalized support and guidance. The findings identified collaborative learning, case-based learning, and contextual learning (C3), as the design components that may foster ethical practices. The C3 model presents a synergistic framework for the design of online RCR courses that facilitate active and interactive learning

Strand 14: Environmental Education
Modelling, Assessment, and Promotion of Climate Literacy
3:45 PM-5:15 PM, Portland
Discussant: Hui Jin, Educational Testing Service
Presider: Ute Harms, IPN - Leibniz Institute for Science and Mathematics Education

Modelling, Assessment, and Promotion of Climate Literacy
Ute Harms, IPN - Leibniz Institute for Science and Mathematics Education
Hui Jin, Educational Testing Service

Towards a Heuristic Model for the Development of Climate Literacy
Ute Harms, IPN - Leibniz Institute for Science and Mathematics Education
Dirk S. Mittenzwei, IPN - Leibniz Institute for Science and Mathematics Education
Hanno Michel, IPN - Leibniz Institute for Science and Mathematics Education

Exploring the Epistemic Orientations of Eighth Graders in a Unit on Weather & Climate
Nathan Quarderer, University of Iowa
Gavin W. Fulmer, University Of Iowa

Assessing Climate Literacy – Development and Implementation of a Multidimensional Assessment Instrument Subject
Dirk S. Mittenzwei, IPN - Leibniz Institute for Science and Mathematics Education
Hanno Michel, IPN - Leibniz Institute for Science and Mathematics Education
Ute Harms, IPN - Leibniz Institute for Science and Mathematics Education

Fostering Secondary Students' Evidence-Based Reasoning about Earth's Climate with Models
Devarati Bhattacharya, University Of Nebraska–Lincoln
Kimberly Carroll Steward, University Of Nebraska - Lincoln
Cory T. Forbes, University Of Nebraska–Lincoln
Mark A. Chandler, Columbia University

ABSTRACT
Several studies show that students often lack conceptual knowledge and show multiple misconceptions when explaining climate change. Hence, it is often argued that science education should focus on conveying sufficient conceptual knowledge about climate change, its causes, consequences, and potential ways of adaptation and mitigation. However, besides scientific content knowledge, decision-making, and the intention to act in the context of climate change seem also to be influenced by non-scientific factors such as attitudes and value attribution. The USGCRP (2009) thus promotes to focus education on climate literacy, which includes specific knowledge about climate change, abilities and attitudes relevant to act in a climate protecting manner. So far, evidence based teaching approaches for education about climate literacy, as well as research studies examining the impact of climate literacy on actual decision-making and intention to act, are rare. In this symposium, we aim to elaborate how climate literacy can be modelled, how its different dimensions can be efficiently assessed, and how it can be promoted through meaningful instruction. In conclusion, we aim at providing an overview on the current challenges in climate literacy research and how they could be addressed in the future.

3/18/20

Concurrent Session 11
8:30 AM-10:00 AM

NSTA
Admin Symposium-Translating your Research into Forms that are Useful to K-12 Science Educators
8:30 AM-10:00 AM, Eugene
Discussant: Norman G. Lederman, Illinois Institute Of Technology

Valarie L. Akerson, Indiana University
David Crowther, University of Nevada Reno
Judith Lederman, Illinois Institute Of Technology
Victor D. Sampson, University Of Texas At Austin
Kathy Trundle, Utah State University

Strand 1: Science Learning, Understanding and Conceptual Change
Understanding of Climate and Natural Systems
8:30 AM-10:00 AM, Salmon
Presider: Asli Sezen-Barrie, University of Maine

Assessment of Students' Explanatory Models for Conceptual and Epistemic Quality: The Case of Ocean Acidification (OA) and Its Impacts on Oysters
Asli Sezen-Barrie, University of Maine
Mary K. Stapleton, Towson University
Anica Miller-Rushing, University of Maine

ABSTRACT
This study explores an assessment framework through research-based analysis of 152 explanatory models developed by students across 15 classrooms about ocean acidification and its impact on oysters. Explanatory models help students integrate their previous ideas and then revise these ideas with evidence collected through investigations, observations, and credible resources to gain an explanatory power. In our project, students' explanatory models respond to the scientific question: "How will increasing levels of CO2 affect oysters?" Using MultiModal Discourse Analysis (MMDA), we explored what components of explanatory models makes them rigorous, i.e. respond to the scientific question with an evidence-based explanation. The assessment framework we described suggests that we can look at the essential, evidence based scientific ideas for the scientific questions and the mode (e.g., drawing, writing) by which these ideas were integrated into the model. Moreover, we suggest looking at scientific representations and systems thinking to help sequence and clarify the relationships and processes. Finally, we recommend identifying alternative conceptions to understand what ideas might limit scientifically accurate explanation. Our findings showed that currently, students have challenges with developing high quality models. Therefore, the assessment framework can be adjusted and used by teachers to scaffold students' learning to develop explanatory models.

Climate Education in Secondary Science: Comparison of Model-Based and Non-Model-Based Investigations of Global Climate Data

Devarati Bhattacharya, University Of Nebraska
Kimberly Carroll Steward, University Of Nebraska - Lincoln
Cory T. Forbes, University Of Nebraska–Lincoln
Mark Chandler, Columbia University

ABSTRACT

Secondary students are increasingly being afforded opportunities to use authentic data to investigate the Earth's climate and global climate change (GCC) in science classrooms. Though these approaches often involve modeling tools, there is limited research on if and, if so, how, models may enhance students' evidence-based reasoning about GCC. Here, we investigate the comparative effectiveness of two strategies -model-based and non-model-based inquiries -,in supporting students to use data to reason aboutGCC.Within the context of a 3-week, project designed curriculum, we analyzed student tasks (data-based activity, n =50 and model-based activity, n=50) and student interviews (n = 10) from ten 9th-grade geoscience classrooms using the Evidence-Based Reasoning Framework (Brown et al., 2010). Results show that the affordances provided for data-based reasoning are different between the two approaches (Mnon-model-based=1.41, SD=1.39) and Mmodel-based=2.39, SD=1.34), t(94)=3.45, p=.0008. Non-model-based inquiry facilitated quantitative investigation of temperature data from 1881-2017. Students calculated temperature anomalies in Excel and identified and described the time-series graph created by them. Comparatively, model-based inquiry facilitated both qualitative and quantitative analysis of "big data" through multiple modalitiessuch as time plots and visualizations, leading to a more deductive and robust reasoning.

Making community experiences and knowledge visible in modeling local climate systems

Heather F. Clark, University of California, Los Angeles
William A. Sandoval, University of California, Los Angeles

ABSTRACT

The need for locally relevant science education that honors students' community-based knowledge as legitimately scientific has long been established. We aim to contribute to how we, as researchers, grapple with conceptualizing community-based scientific knowledge in documenting student learning outcomes. Drawing on data from a design-based research project that developed a climate science intervention, this paper aims a) to make visible the analytical strategies employed in coding students' diagrammatic models of local climate systems and b) to share changes in students' understanding of the concepts and practices of climate systems. We interrogate how a holistic rubric used to score student learning outcomes served to link our design conjectures to classroom artifacts anchored in students' personal experiences with the local context in which they observe climate phenomenon. Results from rubric scores showed that when learning was designed around community-based experiences, students' understanding of the concepts of climate science and the practice of modeling marginally improved. By analyzing our categorical and coding strategies that aimed to position students' community knowledge as scientific, we hope to better understand how science education can address power and place alongside science in climate change learning.

Preschool Children's Understandings of Food Webs Throughout a Summer Camp Experience
Lisa A. Borgerding, Kent State University
Fatma Kaya, Kent State University

ABSTRACT
This study explores preschool children's understandings of food webs throughout a one-week summer STEAM camp addressing feeding relationships in a forested environment. Previous research has identified how children are better able to reason up a food chain in terms of a prey population impacting a predator population compared to reasoning down a food chain in terms of a predator population impacting a prey population. These relationships were explored with a sample of preschool children aged three through five. Data sources included pre- and post- assessments of several feeding relationships including producer abundance, prey abundance, herbivore starvation, predator starvation, over-predation, and under-predation. Additional data sources included field notes of whole group instruction, dramatic puppet play, and dioramic toy play. Data analysis entailed scoring pre- and post-assessments and using the constant comparative method to code field note transcripts. In terms of results, children showed modest pre to post gains but did not differ in terms of their abilities to reason up and down food chains. The qualitative analysis identified several food chain reasoning challenges including anthropomorphism, consideration of prey as "enemies," and consideration of prey and predators as "friends." Implications for instruction and future research are included.

Students' Plausibility Shifts and Knowledge Gains When Evaluating Competing Explanatory Models about Freshwater Resource Availability
Timothy Klavon, Temple University
Janelle M. Bailey, Temple University
Doug Lombardi, University of Maryland, College Park
Archana Dobaria, Temple University

ABSTRACT
Critique and evaluation are considered essential to deeper science learning. Furthermore, critical evaluation may influence plausibility judgements about explanations through re-appraisal. We developed the YIS-activity (blinded for peer review) to activate students' epistemic judgements (i.e., plausibility) about competing models explaining scientific phenomena and to further their learning about Earth science topics. This study seeks to answer the question, "How are the plausibility shifts and knowledge gains of students impacted by the evaluation of multiple explanatory models for the future availability of freshwater resources?" Participants ($N=76$) completed a YIS-activity about freshwater resources, including pre and post-instruction knowledge surveys and plausibility ratings. Paired-samples t-tests determined that the students showed significant knowledge gains [$t(75)=4.46$, $p<.001$, $d=0.51$]. Initial analysis of the omnibus plausibility shifts was not significant, however particular knowledge item score differences caused us to re-evaluate the plausibility relationships between the three presented models. Two models each showed significant differences with the third model, [$t(75)=2.66$, $p<.001$, $d=0.30$] and [$t(75)=2.94$, $p=.004$, $d=0.33$] respectively. These two models also did not have a significant plausibility shift between themselves. While students accomplished significant learning in the YIS-activity, this finding emphasizes the difficulty that students have when evaluating multiple scientific explanatory models.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Motivating Youth Engagement

8:30 AM-10:00 AM, Hawthorne/Belmont/Laurelhurst

Presider: Jonathan Shemwell, University of Alabama

Influences of Worldview and Knowledge on Climate Change Discourse: Evidence for Ideologically-Motivated Reasoning among Youth

Lynne Zummo, Stanford University
Brian M. Donovan, BSCS
K.C. Busch, North Carolina State University

ABSTRACT

Climate change remains divisive in the US, where skepticism of the scientific consensus is associated with political conservativeness (Mildenberger, 2019). However, how politics affect youth and their perceptions of climate change has been studied only minimally. This study deepens our understanding of how political views influence American youths' reasoning about climate change. It used mixed-methods to clarify how worldview, mechanistic knowledge, and interactions between the two influence youths' discourse. We analyzed the results of an individually randomized trial with clustering involving 357 participants in grades 9-11 from 5 sites across the US. Applying generalized estimating equations, we found: 1) exposure to mechanistic knowledge about climate change increased odds of expressing concern over climate change (OR=2.29; p=0.034); 2) having politically conservative worldviews decreased odds of expressing concern (OR = 0.157; $p < 0.001$); 3) worldview and quantitative reasoning level interacted for conservative students to decrease odds of expressing concern (OR = 0.33, $p < 0.001$). This study demonstrates the influence of worldview on acceptance of climate change for youth, yet also demonstrates the value of teaching mechanistic understandings. It shows that moving Americans toward the scientific consensus is complex and involves confronting ideologically-motivated reasoning, even among youth.

Social Interdependence of Young Adolescents during a Smart-Greenhouse Project in a Required Science Class

David W. Jackson, Boston College
Pablo Bendiksen Gutierrez, Boston College
Amy R. Semerjian, Boston College

ABSTRACT

Embedding computational thinking into classes outside of computer science (CS) is an important yet elusive challenge for educational designers, as education in computation becomes increasingly important -- and often inequitable -- with proliferation of technology. There is a lack of empirical work for teaching computational thinking in non-CS classes, especially with young adolescents. We report on the second iteration of design-based research in an urban-ring city of Massachusetts, for which computational thinking was embedded in two required environmental science classrooms (N=165 students). Youth completed a 15-hour smart-greenhouse project, wherein each team of 3-4 individuals constructed an automated miniature greenhouse to grow basil or lettuce. Adopting a lens of social interdependence theory (Johnson & Johnson, 2009), we conducted a mixed research study for explanation, using qualitative data to explain findings from pre- and post-surveys. Despite a lack of statistically significant differences between students' self-reported cognitive, emotional, or social engagement (Fredricks et al., 2016) from the project relative to previous group work in science class,

qualitative analyses revealed relationships that might promote or inhibit engagement in computation. Our findings have implications for educational designers embedding computational thinking in non-CS classes, as well as researchers moving towards more social conceptions of student engagement.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Characteristics of the Learning Environment
8:30 AM-10:00 AM, Mt Hood
Presider: Jeanna R. Wieselmann, Southern Methodist University

"Integrating" Investigations into Science Teaching: What Are Essential?
Lin Zhang, Providence College
Jennifer Van Reet, Providence College

ABSTRACT
The integration of scientific investigations has remained focus in science teaching over decades. Influenced by the constructivist view, scientific investigations are viewed as a tool for students to construct their own knowledge and are often characterized as not directly telling answers, but engaging students in hands-on investigation steps to find the answers. We conducted this study to detach two instructional elements that often co-occur in characterizing scientific investigations in science teaching, playing and telling, simply called, and tested their effects on students' learning of science concepts. Our study raises concerns with the commonly advocated approach to scientific investigations and provides insightful information into understanding the instructional roles of the two elements in science learning activities.

Characterizing Epistemic Messages that Support the Development of Student Intellectual Authority in the Classroom
Susan B. Kelly, University of Illinois
Stina Krist, University of Illinois at Urbana-Champaign

ABSTRACT
Developing a classroom community where students' ideas are central, and positioned to do the intellectual work is a principal goal of current education reform efforts (NRC, 2012; NGSS, 2013), and a challenging one. Teachers communicate what knowledge "counts," and how students should participate with respect to their ideas through the epistemological messages they send (Russ, 2018). These implicit messages are thought to be ever-present and reified through moment-to-moment interactions. In this paper, we investigate the epistemic messages one expert teacher sends as he works to shift the intellectual authority to his students, positioning them to take on more of the knowledge building during an Earth Science unit in his 8th grade classroom. In order to begin to empirically identify specific epistemic messages and how they come to be produced, we present initial analyses of two videos, one from the beginning and the end of the unit, and conduct a micro-analysis of classroom interactions to identify the implicit messages he sends about learning, and how students interpret them. In this analysis, we identified three epistemic messages the teacher communicates and that students take up in their own knowledge building. We characterize them qualitatively and examine their frequency.

Developing and Teaching Science Textbooks' Content According to STEM Education Approach:The Centralized Educational System Context

Mohammed A. Aljallal, Riyadh Educational Administration, Ministry of Education, Saudi Arabia. Excellence Research Center of Science and Mathematics Education ECSME, King Saud University.
Saeed M. Alshamrani, Department of Curriculum & Instruction, College of Education, King Saud University. Excellence Research Center of Science and Mathematics Education ECSME, King Saud University

ABSTRACT

This paper proposes two models for developing and teaching science textbooks' content in ways that are consistent with the STEM approach in the context of centralized educational systems. These systems require teachers to cover specific science content in ways that is not well integrated with other subjects. In this paper, we propose two models, each developed to allow teachers to present the related disciplines of technology, engineering, and mathematics more cohesively while continuing their use of their science textbooks. Data were collected through interviews and observations as the researchers studied the issue of broadening current science teaching methods by elaborating on existing textbook science content with related mathematics, technology, and engineering content. The researchers sampled 15 participants and 3 science topics to achieve the triangulation and within-case nests to understand the issue. The data were analyzed through the Typological Analysis Model, which led to the generalization that it is possible to successfully use the proposed models in the context of centralized educational systems where teachers are required to teach using the centralized education system selected textbook. The researchers conclude with considerations which may support science teachers in the use of the models.

Experience Characteristics and Knowledge Sharing Interactions in a Field-Based Paleontology Social Network

Richard T. Bex, University of Florida
Corey A. Payne, University Of Florida
Jennifer E Bauer, University of Florida & University of Michigan
Kent J. Crippen, University of Florida
Jeanette Pirlo, Florida Museum of Natural History

ABSTRACT

Examining interactions between people has the ability to help us better understand the characteristics of learning as a social network and how this is influenced by context. This study, rooted in the communities of practice framework, involves an investigation of a paleontological field experience during an imaging and digitization workshop. Interaction data was collected through field observations and a survey, which asked participants to indicate how much information they provided to each participant during the workshop's field experience. Using social network analysis software, two separate social networks graphs (observed and perceived) were created and analyzed. Results indicate there was no effect of experience on an individual's centrality within the network. Additionally, while there was a significant difference in the number of interactions a participant perceives compared to what was observed during the field experience, it did not make a large impact the flow or structure of the network. This study makes an important contribution by examining examining the effect of individuals' experience levels and how those individuals interact and share science knowledge in the context of paleontologic field environments. It also details a method for future research in science education contexts that are rarely studied.

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

Early Childhood Scientific Thinking

8:30 AM-10:00 AM, Meadow Lark/Douglas Fir - 3rd floor

Presider: Emily C. Miller, University of Wisconsin Madison

A Study of the Impact of an Early Childhood Intervention on STEM Learning

Charlene M. Czerniak, University Of Toledo
Peter Paprzycki, University Of Toledo
Grant Wilson, The University of Toledo
Jeanna Heuring, The University of Toledo
Susanna Hapgood, The University of Toledo
Joan Kaderavek, University Of Toledo
Scott Molitor, The University of Toledo

ABSTRACT

The context for this study was an intervention that provided professional development (PD) for preschool (pre-K) and kindergarten (K) teachers and science engagement activities for families. The research sought to determine the impact of the intervention and the extent to which parent engagement adds to student learning. This quasi-experimental study utilized an analysis sample of 317 pre-K and 87 K students drawn from six elementary schools in the Midwest. The design included control, PD-only, and PD+ family engagement groups. A General Linear Model (GLM) was used to assess the effects of treatment groups on Rasch model calibrated Early Learning Scale (ELS) Spring 2019 measures. Fall 2018 pre-test ELS scores and gender were used as covariates. The model supported statistically significant gains for the PD-only and PD + family engagement groups visa vie the control group for the pre-K sample and a statistically significant gain of the PD + family engagement group visa vie the non-treatment group for the K-level sample. All effect sizes (Hedges' g) ranged from 0.25 to 0.26, which are considered substantive. The added impact of family engagement over and above the effect of PD-only intervention was not definitive in the study and needs to be further investigated.

Kindergarten Students' Emerging Particle Models of Matter

Alaina Pearl Glidden, Purdue University - Department of Curriculum and Instruction
Bima Sapkota, Purdue University - Department of Curriculum and Instruction
Krista Hook, Purdue University - Department of Curriculum and Instruction
Lynn A. Bryan, Purdue University - Center for Advancing the Teaching and Learning of STEM
Ala Samarapungavan, Purdue University - Department of Educational Studies

ABSTRACT

In this multiple-case study, we investigated how six kindergarten students demonstrated their understanding of the particulate nature of matter through modeling. During a modeling-/inquiry-based unit, children drew model predictions and observations to represent each state of matter (i.e., solid, liquid, and gas) and phase change (i.e., freezing, melting, evaporation, and condensation). Modeling activities within the instructional unit included iPad-based simulations; large and small group discussions; and construction, description, and revision of several types of models. Based on student-constructed science notebooks and video recordings of the taught lessons, our findings demonstrate that kindergarteners began to adopt microscopic particulate models to represent the properties and behavior of matter as they progressed through modeling activities, suggesting that modeling activities enhanced children's conceptions of matter from solely macroscopic to microscopic

composition/arrangement. However, some of their models did not demonstrate an understanding of the differences in particle motion and/or arrangement of particles for each of the states of matter. Further, some children used a mixed perspective (particle and macroscopic) to demonstrate multiple related aspects of a phase change. Consistent with previous research, these findings suggest that young children can learn to represent properties and behavior of matter microscopically when immersed in a scaffolded, modeling-/inquiry-based learning environment.

To What Extent Does The Lab Center Influence Preschoolers' Inquiry, Self-Regulation, and Metacognitive Capabilities?

Ornit Spektor-Levy, The School of Education Bar Ilan University Israel
Ronit Fridman, The School of Education Bar Ilan University Israel
Netta Perry, The School of Education Bar Ilan University Israel

ABSTRACT

Young children are able to hold abstract, intuitive, and causal theories, and can evoke exploratory processes. Exploratory processes require deployment of self-regulation and metacognitive capabilities. Thus, it is paramount to understand to what extent these abilities are developed and which practices can enhance these abilities. Therefore, we sought to design a play-like-scientific task and to analyze preschoolers' responses. Moreover, we aimed to study the influence of an intervention program that encompassed the design of an inquiry center—The Lab—in preschool classrooms. To this end we asked: In what ways do preschoolers manifest inquiry, self-regulation and metacognitive capabilities during engagement in scientific exploration? To what extent does The Lab Center influence these capabilities? Each child (N=200) was documented (pre-and post-intervention) by video during engagement in open exploratory task. Responses were analyzed using a detailed qualitative and quantitative coding scheme. Findings revealed that young children show indications of metacognitive and self-regulation abilities while engaging in inquiry practices. They can plan and monitor their explorative behaviors, and with appropriate intervention can improve their capabilities. The activation of The Lab Center as an integral part of the learning environment enhanced the participants' levels of performance in most inquiry, metacognition, and self-regulation variables.

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

Intersecting Earth science and Engineering concept in the classroom

8:30 AM-10:00 AM, Salon E

Presider: Matthew Johnson, Pennsylvania State University

Impact of Engineering Design Integrated Science on Student Learning Outcomes

Laura O. Pottmeyer, Carnegie Mellon University
Frackson Mumba, University Of Virginia

ABSTRACT

This study examined the impact of engineering design integrated science (EDIS) instruction on student learning outcomes in both science and engineering design. The study was guided by the Opportunity to Learn (OTL) theoretical framework, which says that student learning is impacted by the opportunities provided to students to learn the curriculum. Participants were 460 high school students, who received EDIS instruction from the pre-service teachers. First, pre-service science teachers learned about engineering design and how to plan for and teach EDIS units in their science methods course. Then, they

implemented their EDIS units in high school classrooms during their student teaching placements. Data sources were unit plans, pre and post-tests, and survey. Results indicate that across all classrooms, students demonstrated a statistically significant increase in their science content knowledge, understanding of the engineering design process, and their perceptions of engineering design, after EDIS instruction. Furthermore, regression analysis revealed that a high OTL environment was beneficial for students who performed low on the science content and engineering design content tests before instruction. These findings have implications for teacher education, and teaching and learning of engineering design and science instruction in schools.

Instructional Differences in the Support of System-Level Mechanistic Models of Plate Tectonics

Scott McDonald, Pennsylvania State University
Kathryn M. Bateman, Temple University
Arzu Tanis Ozcelik, Aydin Adnan Menderes

ABSTRACT
This study describes two instructional contexts where students were engaged with learning plate tectonics in middle school. Learning gains based on changes in pre/post conceptual interviews were used as a foundational difference between the two contexts. Video recordings of instruction were then analyzed to connect differences in the enactment and the opportunities students were provided to learn with changes in their understandings of plate tectonics. Overall, efforts by one instructor to create coherence, provide students agency, and grounding instruction in a central phenomenon all contributed to improved student understanding.

Middle School Students' Understanding of Lunar Phases: A Quasi-Experimental Study

Merryn Cole, University Of Nevada Las Vegas
Jennifer A. Wilhelm, University of Kentucky

ABSTRACT
This study examines differences within and between groups of middle school students' spatial-scientific development from pre- to post- implementation of an Earth/Space unit. One group (N=155) experienced a purposeful, spatially-integrated Earth/Space unit while the other (N=72) experienced their Business as Usual (BAU) unit. The research questions framing this study were: In what ways do students' curricular and instructional experiences affect their spatial-scientific learning? What, if any, differences in understanding exist between gender groups? Students in the Treatment group kept daily moon observation journals throughout the unit, which were collected along with pre- and post- assessment data (LPCI) and video recordings of two lessons from each teacher. There was a significant difference between the Treatment and BAU groups on the LPCI. There was also a significant difference between teachers, with one Treatment teacher's students scoring significantly better than others. Her students showed an increase in spatial-scientific understanding twice as large as others. Possible explanations include the moon journals, teachers each adapting the curriculum differently, and differences in teachers' content knowledge. Better understanding the reason for differences between teachers will help with developing more focused professional development for teachers with an effect of better preparedness for all students' STEM achievement.

Science Teachers' Goal Conflicts when Integrating Engineering into Science Classes

Todd L. Hutner, The University of Alabama
Victor D. Sampson, University Of Texas At Austin
Christina L. Baze, University of Texas at Austin
Lawrence Chu, The University of Texas at Austin
Richard H Crawford, The University of Texas at Austin

ABSTRACT
The Framework for K-12 Science Education details new goals to guide improvement efforts for US science education. Among the new goals, the inclusion of engineering core ideas and practices alongside science core ideas and practices stand out. Prior research shows adoption of new goals does not lead to disengagement from older goals. Instead, previously adopted goals often remain influential, resulting in conflict between goals. The purpose of this paper is examine goal conflict that arises when teachers adopt new goals related to teaching engineering core ideas and practices. We report a case study of four 8th grade science teachers at a single middle school implementing a new engineering instructional framework. The primary data for this study come from eight semi-structured interviews conducted at significant project milestones. Findings indicate that there were four goal conflicts, grouped under two categories, which all four teachers experienced. Under the allocation of resources category, all four teachers expressed goal conflict related to allocation of money and allocation of time. Underneath the district coordination category, all four teachers expressed goal conflict related to the district required curriculum and district mandated benchmark testing. Each teacher also experienced unique goal conflicts, detailed in the full paper.

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

Using representations to learn science

8:30 AM-10:00 AM, Salon F

Presider: Nicole Graulich, Justus-Liebig Universität Giessen,

Development of a Framework for Studying Abstraction in Undergraduate Physical Chemistry

Jessica Karch, University of Massachusetts Boston
Hannah Sevian, University Of Massachusetts Boston

ABSTRACT
Although the capacity for domain-general abstraction is developed at a young age, undergraduate students often struggle to abstract in increasingly complex and disciplinary environments. In undergraduate physical chemistry, this difficulty with abstraction combined with the abstractness of the content creates a barrier to student success. However, an adequate framework to study this phenomenon at the tertiary level does not exist. In this paper, we draw on multiple theoretical perspectives and an empirical analysis of three critical cases to formulate a framework to analyze abstraction processes in physical chemistry problem solving. Specifically, we conceptualize abstraction as an activity and propose five actions that exist on a scale of increasing abstractness. By mapping how pairs and individuals use these five actions (concretizing, manipulating, modeling, generalizing, and knowledge constructing) while solving complex physical chemistry problems, we show (1) abstraction tends to occur only when the individual perceives a need, (2) actions at lower levels of abstractness (e.g. concretizing) often precede successful abstraction, and (3) solving problems more abstractly does not equate to solving them more correctly. Using these critical cases, we show how this model can be applied to understand how and when students may succeed in physical chemistry problem solving.

Effects of Dynamic and Static Cueing in Instructional Videos on Students' Conceptual Understanding in Chemistry

Nicole Graulich, Institute of Chemistry Education, Justus-Liebig Universität Giessen
Sascha Bernholt, IPN – Leibniz Institute for Science and Mathematics Education, Kiel, Germany
Marc Rodemer, IPN – Leibniz Institute for Science and Mathematics Education, Kiel, Germany
Julia Eckhard, Institute of Chemistry Education, Justus-Liebig Universität Giessen

ABSTRACT

Decoding and interpreting representations is a fundamental competence for learning in the science disciplines. In chemistry, students are confronted with a variety of structural representations and symbols. Interpreting these structural representations is the bottleneck for understanding organic chemistry and probably the most challenging task for students. Research findings in chemistry education agree that one central reason for students' difficulties with reaction mechanisms lies in the (missing) link between the representation and the chemical concepts. Evidence from cognitive learning sciences indicates that cueing on relevant features of a representation can facilitate the learning process. This quantitative study investigated the effect of different cueing techniques in instructional videos on students' conceptual understanding in organic chemistry at the college level. For this purpose, an adapted dynamic highlighting approach, compared to eye movement modelling examples of an expert was compared to conventional static highlighting based on color-coding in a randomized controlled-trial. Preliminary findings show that students' performance increased significantly in implemented comprehension tasks, which measured students' direct attention after watching the tutorial, comparing the dynamic and static cueing group and the control group. Overall findings will be presented and implication for future learning with digital media in organic chemistry are outlined.

Exploring Student Strategic Flexibility: System Choices for Energy Analysis in Physics

Grace Elizabeth Baker, Seattle University
Thanh K. Le, Western Washington University

ABSTRACT

One approach to supporting student problem solving in physics is to promote the use of multiple representations (e.g., words, graphs, pictures, and equations). Representation use involves between representation fluency and within representation fluency. There are two components to within representation fluency: knowing multiple strategies within a representation and choosing the most appropriate strategy for a given problem. The present study focuses on undergraduate students within representation about their system choices when applying the work-energy theorem. We used think-aloud interviews to explore student rationales for their system choices. Twenty-three undergraduate students enrolled in a calculus-based mechanics course participated. Results revealed students used three factors to base their choices. The first factor is on their self-assessment of their content understanding. The second factor is on their prior experience with similar scenarios. The last factor is their perceived effort or simplicity of their choices.

Investigating simulation use on student learning outcomes in introductory physics

Emily C. Allen, Boston University
Andrew Duffy, Boston University
Manher Jariwala, Boston University

ABSTRACT
The use of computer simulations in physics education is a growing and evolving practice. In this paper, we report the results of a two-year study on the development and analysis of computer simulations and supporting instructional materials for the topic of momentum conservation. In an algebra-based, studio physics course for life science students at a large, private, R1 institution, the designed simulation was implemented into a traditional, two-cart collision lab activity in place of hands-on equipment using a quasi-experimental design. Learning outcomes were measured over two years by comparing student performance on written post-lab exercises, midterm and final exam scores, and pre- and post-test scores of the Energy and Momentum Conceptual Survey (EMCS). In assessing student mastery of the subject matter, we found no significant differences on written assessments for momentum-related learning outcomes between students using only the simulation in the experimental group, and students using only hands-on lab equipment in the control group. Our results continue to add to the growing body of evidence for better understanding the use of computer simulations in place of hands-on equipment for lab activities in physics.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Empowering emerging postsecondary educators
8:30 AM-10:00 AM, Salon D
Presider: Robert Idsardi, Eastern Washington University

An Exploration of Biology Graduate Students Ambivalent Perceptions of the Research-Teaching Ecology
Joshua W. Reid, Middle Tennessee State University
Grant E. Gardner, Middle Tennessee State University

ABSTRACT
Despite recommendations to implement evidence-based instructional strategies (EBIS) in post-secondary STEM courses, many instructors in these classrooms still use traditional methods of instruction. Post-secondary instructors' perceptions of the relationship between research and teaching may offer insight into why they rely on traditional teaching methods. These perceptions are developed and cemented during their graduate studies. This presentation will disseminate findings from part of a larger study exploring how biology graduate students perceive the relationship between research and teaching and provide empirical data to support or refute literature claims as to what influences these perceptions. Guided by Bronfenbrenner's Ecological Systems Theory, we constructed and disseminated a cross-sectional survey aimed to elicit biology graduate students' perceptions of the relationship between research and teaching. Findings indicated that biology graduate students hold synergistic perceptions. However, this is in contrast to the ambivalent social and cultural messages that biology graduate students are receiving. This work contributes to the growing literature on biology graduate students, specifically related to the implicit theories about their perceptions of their professional roles.

Engaging Undergraduate Learning Assistants in Formative Assessment in Large STEM Classes
Young Ae Kim, University of Arizona
Katelyn Southard, University of Arizona
Jonathan Cox, University of Arizona
Lisa Elfring, University of Arizona
Paul Blowers, University of Arizona

Vicente A. Talanquer, University of Arizona

ABSTRACT
This qualitative study explored how learning assistants trained to focus on formative assessment in the classroom gathered and analyzed student thinking data, and then generated daily reports to inform instructional practice. This study centered on the analysis of the written reports and individual interviews, to characterize how these "Learning Researchers" (LRs) approached their task, and the affordances and challenges in their formative assessment practices. Our analysis revealed that initially most LRs attended to issues related to student engagement and to the correctness of students' products, adopting an evaluative stance in the assessment of students' ideas. Their early reports lacked specificity and their claims were rarely supported with evidence collected in the classroom. Over time, most LRs shifted their attention to student thinking and suggested avenues for improving student understanding. Undergraduate LRs showed a great potential as effective collaborators in promoting formative assessment. At the same time, they struggled to notice, interpret student thinking, and provide constructive suggestions for designing learning tasks to foster student learning. Our findings contribute to the understanding of alternative avenues to promote systematic formative assessment in large college classrooms and engage instructors in reflective practice by focusing their attention on student thinking.

Exploring Sources Of And Changes In Graduate Teaching Assistant Teacher Efficacy Throughout A Semester

Cody Smith, University of Nebraska-Lincoln
Cesar Delgado, North Carolina State University

ABSTRACT
This study explored changes in and sources of teacher efficacy over a semester among graduate teaching assistants (TAs). TAs' demographics were surveyed, and teacher efficacy was measured pre-, mid-, and post-semester using the Graduate Teaching Assistant Teacher Self Efficacy Scale. Interviews were used to explore what influenced TA teacher efficacy. The most experienced TAs had higher teacher efficacy than the least experienced. Teacher efficacy significantly increased from pre- to mid-semester with a slight decrease from mid- to post-semester. High-efficacy TAs were primarily influenced by mastery experience, vicarious experience, and verbal and social persuasions from professors and accomplished peers. Low-efficacy TAs were primarily influenced by mastery experience of self-oriented teaching skills, vicarious experience, and verbal and social persuasions from students. The lack of mastery experience and lack of content knowledge also emerged for low-efficacy TAs. The language of high-efficacy TAs demonstrated evidence of focusing outwardly on their impact on student learning, while low-efficacy TAs demonstrated evidence of focusing inwardly on their own selves. A proposed model of teacher efficacy was developed to inform future research and provide suggestions for TA PD opportunities.

Opportunities for Graduate Teaching Assistants to Make Epistemic Shifts in the Laboratory

Justin McFadden, University of Louisville
Linda C. Fuselier, University of Louisville

ABSTRACT
In introductory science labs, students participate in the co-construction of knowledge with teachers, usually graduate students, during inquiry-driven labs. This is also where students practice science methods and learn about scientific knowledge. Determining the classroom conditions that encourage

students to understand science as a social process that involves knowledge construction by a community of knowers can inform best practices for promoting scientific literacy and an inclusive culture in science. We used Critical Contextual Empiricism (CCE) as a theoretical frame in a qualitative study to examine graduate teaching assistants (GTAs) emerging classroom practice in introductory biology laboratories. We subjected audio recordings of classes, interviews and artifacts to qualitative analysis that incorporated grounded theory, inductive coding and analytical memos. Our analyses revealed four themes in instructor moves: (1) misconstrued understanding of science, (2) impetus for agentic shifts, and (3) leveraging the community. We describe how these themes emerged and their relation to CCE as a tool for science educators to conceptualize laboratory teaching. Our results will be used to promote changes in GTA professional development programs.

Strand 6: Science Learning in Informal Contexts
Science learning through non-traditional ISL experiences
8:30 AM-10:00 AM, Salon C
Presider: Angela Fitzgerald, University of Southern Queensland

Can Laypeople Identify and Judge Scientific Expertise in the Context of Vaccines?
Aviv J. Sharon, Technion - Israel Institute of Technology
Ayelet Baram-Tsabari, Technion - Israel Institute of Technology

ABSTRACT
To better relate school science with everyday life, we need a better understanding of how individuals evaluate trustworthiness of scientific expertise in their lifelong learning of science. Here, we explored this under-studied issue in the context of vaccination, and hypothesize that when vaccine-hesitant parents seek information about vaccines, they prefer trustworthy sources based on their competence, integrity and benevolence. We analyzed 2,583 answers retrieved from social question-and-answer (Q&A) platform "Yahoo! Answers" (YA), to discover what features of the answers predict perceived answer quality, based on the theory of epistemic trust. Findings indicate that both pro-vaccine and anti-vaccine answers were proportionately represented among "best answers". However, if an answer was written by a health professional, the askers and the community on "Yahoo! Answers" were twice more likely to choose it as the "best answer" to a vaccine-related question. By contrast, an online experiment revealed that the main aspect that determines whether an answer is trustworthy is whether it conforms with the evaluator's stance towards vaccines. These findings reveal that epistemic aims may be counteracted by non-epistemic aims when assessing trustworthiness in socio-scientific issue in everyday life.

Engaging Students in Learning about Climate Change through Filmmaking: A Transformative Educational Experience
Megan K Littrell, CIRES Education & Outreach University of Colorado Boulder
Erin Leckey, CIRES Education & Outreach University of Colorado Boulder
Anne U Gold, CIRES Education & Outreach University of Colorado Boulder
Kelsey Tayne, CIRES Education & Outreach University of Colorado Boulder
Christine Okochi, CIRES Education & Outreach University of Colorado Boulder
Kristin L.K. Koskey, The University of Akron
Toni A. Sondergeld, Drexel University

ABSTRACT
The Lens on Climate Change (LOCC) program engages middle and high school students with place-based, informal science learning through creating short films on climate change in their local communities. The research examined how the program was transformative for students. In this mixed methods study, quantitative analysis of students' responses on the Transformative Experience Questionnaire showed that they were more likely to have a transformative experience if they participated in LOCC than those in a demographically-matched comparison group who did not participate. The transformative experience also did not differ depending on whether they were in middle or high school or whether they participated in an intensive week-long, summer program or an after-school, academic year program, suggesting that the program outcomes were robust across these contexts. Qualitative data analysis supported these findings, showing how LOCC inspired students to apply their learning beyond the program. Also discussed are future applications of this research approach across other, formal learning contexts.

Exploring Science in a Science Fiction Convention Community: Convention Attendees' Perceptions of Science
Gina Childers, Texas Tech University
Donna Governor, University of North Georgia
Kania Greer, Georgia Southern University
Vaughan S. James, University of Florida

ABSTRACT
Science fiction conventions are places where individuals with an interest in diverse genres and mediums can engage with a community that bridges the world of science fiction and fact. Many of these conventions provide a science "track" where science experts share their expertise and research on scientific findings and applications of science in connection to science fiction with science fiction enthusiasts. This study explored and documented interest in science and perceived relevance of science for two groups (n = 242) who attend science fiction convention events: 1) science track (n = 173) and non-science track attendees (n = 69); and 2) educators (n = 59) and non-educators (n = 183). Science track attendees reported significantly higher scores relating to interest in science and perceived relevance of science in their personal lives in comparison to non-science track attendees. Educators and non-educators who attend science fiction convention events did not report significantly different scores relating to interest in science and perceived relevance of science in their personal lives; however, the survey items were scored highly. Because the public has access to science experts through science fiction convention events, it is important to recognize the potential effect conventions can have on science learning.

Situated Escape Games: Facilitating Knowledge and Awareness about Healthy Nutrition
Tal Yachin, Technion - Israel Institute of Technology
Miri I. Barak, Technion - Israel Institute Of Technology

ABSTRACT
Escape games are a new trend in game-based learning, which provides people with the opportunity to learn about science in an informal environment. Escape games are situated in settings that instigate interactions between the players and between them and the learning environment, and therefore correspond with the situated learning paradigm. As escape games are a relatively new trend, research on their design, implementation, and educational value is still in its initial stages. Hence, the current study aimed to develop a model for the design of educational escape games (EduEGs), and to examine

its role in facilitating learning among diverse populations. The study included 54 pre- and in- service science teacher, and 239 adult players. Its data were collected through a survey, observations, interviews, and pre- and post- questionnaires. The intervention included participation in an EduEG on protein consumption and healthy nutrition. The findings indicated that the EduEG was associated with facilitating the situated learning components of authentic situation, scientific information, self-reflection, and collaboration. It also facilitated the participants' knowledge construction and increased their scientific awareness to food-related aspects. The study's results indicated that EduEG can be used for facilitating science education in informal environments.

Thinking Beyond the Conference: Fan Conventions as Places to Communicate Science

Donna Governor, University of North Georgia
Gina Childers, Texas Tech University
Kania Greer, Georgia Southern University
Vaughan S. James, University of Florida

ABSTRACT

Many science fiction conventions provide a science "track" where science experts share their expertise and research on scientific findings and applications of science in connection to science fiction with science fiction enthusiasts. This study surveyed scientists participating as experts (n=19) in the science tracks at a popular science fiction convention to learn 1) about their demographics and background, 2) document their views about the potential benefits and challenges in communicating with the public and 3) what are their opinions related to engaging with the public at science fiction conventions. These science experts cited accessibility and promoting scientific curiosity as the greatest benefits to engaging with the public at science fiction conventions and potential misinterpretation by the audience as one of the greatest challenges. Nearly three-quarters of these experts felt that science fiction conventions were a good place to learn science. Because the public has access to science experts through science fiction convention events, it is important to recognize the potential effect conventions can have on interest and adult learning in science.

Strand 7: Pre-service Science Teacher Education

Preservice Teacher Journaling and Reflection

8:30 AM-10:00 AM, Salon A

Presider: Felicia Moore Mensah, Teachers College, Columbia University

The Effect of Interactive Science Journals on Pre-Service Teachers' Planning and Teaching

Christine Schnittka, Auburn University
Mark Brenneman, Auburn University

ABSTRACT

Over the past two decades, K-12 science teachers have increasingly placed an emphasis on connecting classroom learning to real-life experiences. Teachers look for interesting, creative ways to plan science lessons that students can relate to, looking beyond the textbook, facts, or cookie-cutter experiments to engage students. Teachers find these connections everywhere, but it takes effort to find them. One strategy might be for teachers to create personal journals about science in everyday life. In this study, pre-service science teachers were assigned daily journal writing to make observations, develop questions, and make inferences about the natural world. We studied the lesson plans they created for their field experiences and conducted interviews at the end of the semester. We found evidence of

increased planning for real-world contexts in their lesson plans, as well as increased in-depth observations and questions in their science journals. Interviews served to triangulate these findings, demonstrating that the pre-service teachers valued the process of journal writing, noticing more about science in their individual experiences, and integrating those experiences into their lessons. This study impacts education faculty who work to prepare future science teachers to create learning experiences that connect science to everyday life.

Nascent Impacts of Engaging Pre-service Elementary Teachers with Wonder

Christie C. Byers, George Mason University
Andrew B. Gilbert, George Mason University

ABSTRACT

The purpose of this study was to investigate the impacts of engaging future teachers with wonder within an elementary science methods course as a way to address ongoing challenges in elementary science teacher education. Pre-service elementary teachers (PSETs) were asked to keep a wonder journal and then choose one personal wonder to explore in depth and share with peers during a class wonder fair. Data sources for this instrumental case study included focus group interviews (n=20) midway through the course, exit tickets after the wonder fair on the final day of the course (n=24), and semi-structured interviews six months following the course (n=5). Findings include three discernible impacts that may provide promising entry points toward addressing issues related to teaching through inquiry, a broader understanding of NOS, and increased confidence in capability to teach science.

Developing Shared Conception of STEM Education among Pre-service Elementary Teachers: How Effective is Short Intervention?

Mounir R. Saleh
Hanan Abdo
Faris Alsuliman
Adam AlZayer
Reem Saleh

ABSTRACT

Developing a Shared Conception of STEM Education among Pre-service Elementary Teachers: How Effective is a Short Intervention? Saleh MR, Abdo H, Al-Suliman F, Al-Zayer A, Saleh RM The implementation of STEM education has lately been deemed as needed “now more than ever!” (Bybee, 2018, p.i). However, current literature is abundant of theoretical STEM conceptions that do not provide a clear and practical approach that has implications for teacher education programs. Hence, it is important to develop a shared and practical STEM conception among preservice teachers PSTs as a precursor for productive implementation. The rationale for this study is to investigate whether observing, guided analyzing, and reflecting on a single video-based STEM lesson would help over 70 elementary PSTs to develop a common practical STEM conception. Spanning two 100-minute lectures, participants engaged in the following steps: (a) expressing their STEM pre-conceptions before the intervention; (b) observing and analyzing the video with the guide of the lecturer; and (c) individually reflecting on the observed and analyzed video. Findings indicate that observation, guided analysis, and reflection of a single video-based STEM model lesson helped PSTs to develop a more structured conception for what it looks like for STEM to be included in their classroom. Although more research is needed, these findings can have positive implications for teacher education programs willing to embark on the move for implementation of STEM education.

Strand 8: In-service Science Teacher Education
Supporting Authentic Science Practices
8:30 AM-10:00 AM, Pearl
Presider: Laura Zeller, University of Illinois at Chicago

Developing and Sustaining Lines of Inquiry to Improve Modeling-based Teaching in a Professional Learning Community
Soo-Yean Shim, University Of Washington
Jessica J. Thompson, University Of Washington

ABSTRACT
Few studies have examined how professional learning communities (PLCs) engage in collaborative inquiry over multiple years. In this study, we aimed to explore how a PLC with high school science teachers, district-based coaches, and university researchers developed multiple lines of inquiry to support students' scientific modeling over four years. The PLC was situated in a culturally and linguistically diverse school that experienced high teacher and administrator turnover. We collected and qualitatively analyzed video recordings of the participants' interactions on twelve job-embedded professional development days (about 96 hours) where the participants engaged in cycles of collective planning, teaching, and debriefing of lessons to support students' modeling. We also analyzed artifacts and interview data. Data suggest that, despite the turnover, the participants developed three lines of inquiry to improve sets of instructional practices for modeling-based teaching, specifically aimed at facilitating 1) students' epistemic work of constructing evidence-based models and explanations, 2) students' productive collaboration, and 3) students'—especially emergent bilinguals'— academic language learning through modeling. This study suggests implications about how to study and support teachers' collaboration and improvements in modeling-based teaching over time.

Examining how Professional Development with Educative Curriculum Materials Supports Teachers' Modeling Knowledge and Pedagogical Design Capacity
Karen Lionberger, University of Georgia
Julie M. Kittleson, University Of Georgia

ABSTRACT
Even though science education standards have elevated the practice of modeling over the last few decades, research continues to show teacher knowledge of models and their modeling practices in the classroom remain limited (Wang, Chi, Hu, Chen, 2014). The Science Teachers' Learning (NRC, 2015) report highlights the promising, robust body of evidence that indicates professional development programs can lead to beneficial changes in science teachers' knowledge. Yet, given the limited discipline-specific professional development opportunities for teachers, it is not surprising that the curriculum remains a powerful organizer of teachers' instructional philosophy and classroom practice (Arzi &White, 2007). Recognizing the time teachers must spend reading, translating, and modifying traditional curriculum resources in order to develop classroom practices that reflect reform-based teaching and learning, some efforts to support changes in teacher knowledge and pedagogical design capacity have now focused on doing so through educative curriculum materials (Beyer & Davis, 2009; Davis and Krajcik, 2005). This study utilized a mixed method approach to explore how modeling-based professional development and use of educative performance assessments can support in-service biology teachers' knowledge of scientific models and pedagogical design capacity for modeling instruction.

Changes In Middle School S.T.E.M. Teachers' Drawn Mental Models Of STEM Education Over Time
Matthew Wilsey, Stanford University
Matthew Kloser, University Of Notre Dame

ABSTRACT
Although science, technology, engineering, and mathematics (STEM) education has received significant funding and has become a "buzzword," it is not clear that all stakeholders have common understandings of what counts as STEM education. This study explores how middle school teachers of one of the STEM disciplines – potentially those most responsible for STEM teaching and learning in classrooms – conceptualize STEM education and how those conceptions change, if at all, during participation in a longitudinal professional development (PD). Using drawn mental models as a unique proxy for capturing teachers' conceptions, data was collected from 162 teachers participating in a 2.5-year longitudinal PD focused on improving STEM teaching and learning. Focusing specifically on one component of teacher' conceptions of STEM education – STEM instruction – results suggest that S.T.E.M. teachers' conceptions only partially align with existing frameworks for STEM instruction. Changes were visible, however, in that the percentage of drawn mental models including representations of the integrated nature of the S.T.E.M. nearly doubled from the start to the end of the first summer institute. Additionally, themes of equity and access arose in the teachers' models of STEM over time. Since conceptions can influence classroom behavior, implications for practice and PD are discussed.

Strand 8: In-service Science Teacher Education
Teachers' beliefs, perceptions and knowledge of Socioscientific Issues for global citizenship
8:30 AM-10:00 AM, Salon B
Discussant: Troy Sadler, University of North Carolina at Chapel Hill

Science teachers' pedagogical content knowledge development during enactment of socioscientific curriculum materials
Durdane Bayram-Jacobs, Department of Science Education, Radboud University, Nijmegen, The Netherlands
Ineke Henze, Radboud University, Nymegen
Maria Evagorou, University of Nicosia
Yael Shwartz, The Weizmann Institute Of Science
Elin Leirvoll Aschim, Department of Mathematics and Science Education, University of South-Eastern Norway, Horten, Norway
Silvia Alcaraz-Dominguez, Universitat de Barcelona
Mario Barajas, Universitat de Barcelona
Etty Dagan, Darcaa School Gedera, Israel

Teacher perceptions about using SSI to teach scientific knowledge
Silvia Alcaraz-Dominguez, Universitat de Barcelona

Tension and conflict in implementing SSI as reflected in teachers' beliefs and implementation
Emil Eidin, Michigan State University
Yael Shwartz, The Weizmann Institute Of Science

The Design and impact of SSI Professional Development program
Yael Shwartz, The Weizmann Institute Of Science
Emil Eidin, Michigan State University

ABSTRACT
Learning science for citizenship is a main goal in many national and international policy papers (NGSS, 2012, in the US and Future of Education and Skills 2030 (OECD, 2019). However, research shows a gap between this policy and teaching in practice. As a way to bridge this gap, teacher education is using Socioscientific Issues (SSI) as a way for teachers to develop the knowledge needed to facilitate such a practice. This paper set focuses on means to promote effective professional development by a better understanding of teachers' beliefs and teachers' knowledge. It provides different aspects of interventions and investigations, all of them developed in the framework of the same EU project.

Strand 9: Reflective Practice
Teacher Efficacy, Ownership, and Practice
8:30 AM-10:00 AM, Salon I
Presider: Lisa M. McDonald, Teachers College, Columbia University

Cross-Curricular Planning to Enhance Faculty Practice: An Analysis of Graduate-Level STEM and Diversity Course Instruction
Ebony Terrell Shockley, UMD
Deborah Roberts-Harris, University of New Mexico
Natalie Harr Ylizarde, University Of Maryland
Cachanda K. Orellana, University of Maryland
Kristina Kramarczuk, University of Maryland College Park

ABSTRACT
In order to prepare teachers for elementary science classrooms, this collaborative research focuses on the practices among faculty teaching three different courses (science, digital learning, and diversity) to elementary teacher candidates throughout their teacher preparation program. Based on analyses of student work, faculty self-assess and reflect based on their own learning, knowledge, experience, and preparation for their coursework individually and together with other faculty teaching the same group of students. The lessons learned from shared assignments examined in this study include an increase in technology use and attention to learner contexts and learner experiences in varied field experiences. The project challenged assumptions, enhanced teacher candidate's experiences, and fostered learning among faculty, providing an opportunity for improvements to the remainder of the courses and with future cohorts of science pre-service teachers.

Improving Teacher Efficacy in a Chinese School: A Case Study of Professional Learning Community
Daniel Carpenter, Researcher and Educational Consultant
Qing Gao, Science Teacher and Administrator, Shenzhen China
Brenda L. Carpenter, National Science Foundation

ABSTRACT
This paper reports the findings of a case study that investigated teacher perceptions regarding the establishment of professional learning communities (PLCs), and consequential changes in teacher efficacy of the implementation. The study was conducted at a new and developing K-9 school in South

China. Qualitative data were collected from teachers by making observations, semi-structured interviews, and collecting documents from PLCs. Researchers conducted PLCs virtually and face to face. Data were coded using social constructivism and teacher efficacy frameworks, then analyzed for themes. Results revealed that teachers perceived intensive, job-embedded, content-focused, and ongoing activities as positively impacting teaching and learning innovations and collaborations. Teachers reported that their efficacy improved substantially for activities like formative assessment and mastery teaching and learning enhanced by PLC interactions. The study demonstrated that professional networks found in this school positively impacted socially-based professional learning.

Teacher Ownership for the Proposed Teaching Approaches

Ana Valdmann, University Of Tartu
Jack B. Holbrook, University Of Tartu
Miia Rannikmae, University Of Tartu

ABSTRACT

This presentation puts forward a meaning for the expression ‘teacher ownership’ distinguished this from self-efficacy and impact of action research on the development of teacher ownership. The study follows the development of teacher ownership through two components. Through action research, the ten science teachers want to know whether they accept what they have learned in the prior in-service course and how to create teaching-learning materials based on a new teaching approach and to put this into practice. The second component is how each teacher teaching on their own as they deem appropriate and this can follow ascertained one year later after the action research (in this case). The study seeks to establish categories of science teacher ownership, phenomenographically, basing this on an internalisation of an appropriate philosophy, an interrelated, relevant teaching approach and its effective dissemination to other teachers. Through an analysis of data gathered from portfolios and semi-structured interviews, five dimensions of teacher ownership variation are identified. These variations form the basis for identifying three distinct categories of science teacher ownership, labelled as: emotional, experiential and paradigmatic. These categories are described and the type and level of teacher ownership associated with each and implications are discussed.

Strand 10: Curriculum, Evaluation, and Assessment

Design, Development, and Testing of a Media-Rich Three-dimensional Middle School Science Unit

8:30 AM-10:00 AM, Columbia

Discussant: Katherine McNeill, Boston College

Developing a unit designed for NGSS: Successes and lessons learned in the development process

Lindsey Mohan, BSCS Science Learning
Susan M. Kowalski, BSCS
Betty Stennett, BSCS
Mark Bloom, BSCS
Catherine Stimac, Oregon Public Broadcasting
Heather Young, Oregon Public Broadcasting
Lisa Carey, BSCS Science Learning
Jeffrey Snowden, BSCS Science Learning

Developing a Media-Rich Digital Unit to Support 3D Teaching and Learning
Catherine Stimac, Oregon Public Broadcasting
Heather Young, Oregon Public Broadcasting
Susan M. Kowalski, BSCS
Betty Stennett, BSCS
Lindsey Mohan, BSCS Science Learning
Mark Bloom, BSCS
Jeffrey Snowden, BSCS Science Learning
Lisa Carey, BSCS Science Learning

Professional Development for A Medical Mystery: Moving Beyond the Curriculum
Betty Stennett, BSCS
Susan M. Kowalski, BSCS
Lindsey Mohan, BSCS Science Learning
Mark Bloom, BSCS
Catherine Stimac, Oregon Public Broadcasting
Heather Young, Oregon Public Broadcasting
Lisa Carey, BSCS Science Learning
Jeffrey Snowden, BSCS Science Learning

A Quasi-experimental Study of the Efficacy of a Designed-for-NGSS Unit and PD
Susan M. Kowalski, BSCS
Jeffrey Snowden, BSCS Science Learning
Lisa Carey, BSCS Science Learning
Betty Stennett, BSCS
Lindsey Mohan, BSCS Science Learning
Mark Bloom, BSCS
Heather Young, Oregon Public Broadcasting
Catherine Stimac, Oregon Public Broadcasting

Designing, Developing, and Testing Curriculum and PD for the NGSS: Discussant Remarks
Katherine L. McNeill, Boston College

ABSTRACT
Although a small number of middle school science units are emerging with high ratings on Achieve's EQuIP rubric, very few have been subjected to experimental or quasi-experimental study to examine their efficacy with teachers or students. We present the design specifications, development process, and research findings from a quasi-experimental test of digital, media-rich, designed-for-NGSS middle school science unit related to body systems. We describe the steps taken to ensure the coherence of a single science content storyline, targeted use of media that supports learning goals without diluting the storyline, design and development of teacher materials and PD to support enactment of the curriculum, and research findings from the quasi-experimental study of the unit. Treatment students outperformed comparison students on a test of three-dimensional learning ($p = .04$; $d = .254$).

Strand 10: Curriculum, Evaluation, and Assessment

Investigation of Teacher Knowledge

8:30 AM-10:00 AM, Portland

Presider: Jamie N. Mikeska, Educational Testing Service (ETS)

Knowledge in Use: Examining Elementary Teachers' Content Knowledge for Teaching about Matter using Scenario-Based Assessments

Jamie N. Mikeska, Educational Testing Service (ETS)
Dante Cisterna, Educational Testing Service
Heena R. Lakhani, University of Washington
Luronne Vaval, Teachers College, Columbia University
Allison Bookbinder, Teachers College, Columbia University
David L. Myers, University of Georgia

ABSTRACT

This study explores how teachers across the U.S. answer and reason on assessment tasks designed to elicit content knowledge for teaching (CKT) about matter and its interactions. It leverages a think aloud approach, where participants were asked to reason about different assessment items that described teaching scenarios related to elementary science instruction about topics such as properties of matter, changes in matter, the particulate model of matter, and conservation of matter. Specifically, this study investigates: (1) To what extent do the participants use the intended knowledge and reasoning when responding to items designed to assess their CKT about matter and its interactions? and (2) When participants struggle to respond accurately to these items, what were their reasons for doing so? In particular, we were interested in examining the patterns in the nature of the knowledge they fail to leverage when responding to these CKT matter items. Findings showed that participants' responses aligned to item design rationales, as hypothesized, in approximately 80% of the CKT assessment tasks and how the patterns in their responses helped in assessing the validity of the tasks. This research poses implications for the design and use of CKT assessments in elementary teacher education programs.

Investigating teacher knowledge of NGSS through developing 3D science assessments

Elizabeth X. De Los Santos, University of Nevada, Reno
Candice R. Guy-Gaytán, University Of Nevada

ABSTRACT

This paper reports on the first year of a longitudinal study investigating if and how the development and implementation of a high school biology district assessment influences teachers to shift their practices to align with the vison of science education described in the Next Generation Science Standards. Using qualitative research methods and design, we analyzed a set of semi-structured interviews we conducted with biology teachers who were recruited and trained to write three-dimensional science assessment items. We found that teachers' opportunities to learn about three-dimensional science assessment and therefore develop their three-dimensional science assessment literacy were: (1) influenced by their prior experiences with NGSS, three-dimensional science assessment, conceptions of assessment, and existing assessment practices; and, (2) constrained by the process of developing the district assessment in terms of lack of time and content of item review sessions, which often focused more on science content or grammar than three-dimensional integration or the science and engineering practices and crosscutting concepts. Thus, teacher learning in complex educational systems can be constrained by factors such as time--in this case, the goal of creating a finished product superseded the goal of teacher

learning and development of three-dimensional science assessment literacy.

Assessing Professional Vision of Oral Scientific Argumentation Using Video Annotations

April B. Holton, Arizona State University
J. Bryan Henderson, Arizona State University
Eric Greenwald, University of California, Berkeley, Lawrence Hall of Science
Nicole Zillmer, Authentic Connections
Megan Goss, University of California, Berkeley, Lawrence Hall of Science
Christina Morales, University of California, Berkeley, Lawrence Hall of Science
Lisette Lopez, University of California, Berkeley, Lawrence Hall of Science
P. David Pearson, University of California, Berkeley

ABSTRACT
This paper reports the development of a measure to assess teachers' professional vision of oral scientific argumentation using online video annotation. Teachers were asked to watch segments of videos where students engaged in whole class, small group, and dyad argumentation sessions and annotated the video with what they noticed in these sessions. Based on previous work on professional vision and our larger study on formative assessment of oral argumentation, a coding scheme was developed and tested with a pilot group of participants' annotations. Researchers share initial analysis and findings of this pilot which will be applied to larger data set in a random control trial. The initial findings showed that differences in professional vision existed which aligned with teachers' experience and practice with oral scientific argumentation.

Development of a questionnaire on teachers' knowledge of language as an epistemic tool

Chenchen Ding, University of Iowa
Gavin W. Fulmer, University Of Iowa
Jihyun Hwang, University Of Iowa
Brian M. Hand, University Of Iowa
Jee Kyung Suh, University of Alabama
William Hansen, University of Iowa

ABSTRACT
We report on the development of a new instrument for measuring teachers' knowledge of language as an epistemic tool in science classes. Language is essential for science learning, as all learning requires use of language to constitute one's own ideas and to engage with others' ideas. Teachers with knowledge of language as an epistemic tool can recognize the ways that language allows students to generate and validate knowledge for themselves, rather than to replicate canonical knowledge transmitted by other sources. We adopt a construct-driven questionnaire development approach to ascertain the content, substance, and structure aspects of measurement validity. This process included iterations of domain analysis, item revision, teacher feedback, expert review, and item piloting. Data from 158 preservice and in-service teachers on 27 preliminary items were collected. The response data are analyzed using Rasch measurement modeling. Results informed the revision and selection of 15 items for an instrument available for broader use.

Strand 11: Cultural, Social, and Gender Issues

Exploring Feminism and Materialism in Science Education

8:30 AM-10:00 AM, Salon H

Presider: David M. Sparks, University Of Texas At Arlington

Implications of Materialism Feminism For Chemistry Teaching And Students' Learning

Kathryn Scantlebury, University of Delaware
Catherine E. Milne, New York University
Anita Hussenius, Uppsala University, Centre for Gender Research

ABSTRACT

Science education research is focused on the teaching and learning of chemistry and continues to ignore post-humanistic theories that take into account matter's agency and de-centering the human. A majority of science education research reproduces assumptions that humans have control over nature, that science and thus science education is value free, rigorous, and reproducible research. However, some researchers have used feminist theory to challenge the dichotomies that underpin science/chemistry such as nature/culture, human/objects, matter/ human, research/researcher, subject/object but a majority of these critiques focus on biology or physics. Chemistry (so far) has avoided the feminist gaze but material feminism in conjunction with post-qualitative practices can become the pathway for matter to kick back at chemistry education. This paper discuss how using pedagogical and research practices that intend to deconstruct power hierarchies are a first step in enacting a transdisciplinary research to explore and explain its outcomes.

Learning to Use "The Mill": Material-Embodied STEM Learning in High School Robotics

Colin H. Hennessy Elliott, NYU

ABSTRACT

In this paper I explore the socio-material intra-actions (Barad, 2008) that comprise moments of part fabrication and collaborative learning with the Vertical Mill for youth on a high school robotics team. From a theoratical perspective that explores the unfolding agency of materials, I conclude that the experiences of coming to know how to mill is a connected journey of becoming, where the hands, the body positioning, the Mill, and other materials all become part of the collective knowledge of what to do next. Further, I explore one instance where a young women is not given access to engaging fully with the materiality of the task as an educational injustice which needs to be addressed and prevented to work towards making STEM education more equitable.

South Korean students' and teachers' views of gender in science

Hannoori Jeong, University of Maryland, College Park

ABSTRACT

This exploratory study in South Korea examined how South Korean high school sophomore students and teachers viewed gender bias in science. Studies that examined gender in science have shown findings that in Korea fewer female students choose to engage in science-related activities than male students (Lee and Cho, 1985; Lee, 1996; Yoon, 2002). To examine South Korean students' and teachers' views of gender bias in science in consideration of their unique culture, this study's theoretical framework drew upon the cultural reproduction theory by Bourdieu and Passeron (1990). The findings revealed that the students predominantly held the masculine worldview of science. Further, the teachers were shown to

be less cognizant of their science students. Implications of these findings will be discussed.

Using Scientific Practice to Address the Girls' Crisis: Designing Science Education From a Feminist Perspective
Heather B. Page, New York University

ABSTRACT
Many young women do not see a place for themselves in science evident from the lack of young women entering and persisting in science majors and careers. In this sociocultural study, I created space allowing young women to see science as something they can do and contribute to as they engaged in a unit of study developed from a feminist perspective that used practice as its key pedagogical strategy. I used a design-based research approach to curriculum development and a case study methodology to generate evidence and provide methods for evaluating this identity study. Before implementation, many young women in this study did not consider observation an important part of science.
Evidence demonstrated a change in how they viewed observation, they began to identify observation as tool they could use in science and relate their experiences to those of real scientists. Observation allowed students to see they could contribute to and be part of science. This study has potential to act as a model for developing curriculum and effecting pedagogical change from a feminist perspective at the high school level and to benefit many students who otherwise might not see a place for themselves in science.

Strand 12: Educational Technology
New Methods of Measurement and Analysis to Move the Field Forward
8:30 AM-10:00 AM, Salon G
Presider: Richard Lamb, East Carolina University

An Emotional-Cognitive Approach to Holistically Assessing Computational Thinking and Emotional Constructs for Classrooms and Researchers for Classrooms and Researchers
Amy R Semerjian, Boston College
Mike Barnett, Boston College

ABSTRACT
This study presents a holistic approach to interpreting the measurement of multiple cognitive and emotional constructs relating to technology, computational thinking (CT), computer science, and coding, contextualized within a design-based-research-informed (Barab, 2014), smart greenhouse project embedded into mandatory eighth-grade, public-school environmental-science classes. Assessment was designed to be brief and convenient for teachers, taking roughly 1/3 of a class period. Cognitive CT items were designed both to be closer (Ruiz-Primo, Shavelson, Hamilton, & Klein, 2002) to the smart greenhouse curriculum than other available measures as well as adaptable to other CT curriculum settings. Emotional constructs targeted attitudes towards CT and CS engagement, interest, identity, intentionality, and anxiety more proximally (Ruiz-Primo et al., 2002); these are important because they influence student performance and participation but, unlike demographics, are malleable (Britner & Pajares, 2006). Engagement was emphasized as possibly the easiest-influenced by schools. In practice, embedding CT into existing courses is difficult; in this case, curriculum targeted by cognitive items was not taught in depth, so CT-instrument reliability suffered. Otherwise, results showed well-behaved scales and constructs correlating with each other as predicted, supporting construct validity. Implications include adaptation to other classrooms, the difficulty of the unit being implemented, and

publication bias.

Analyzing Girls' Flow Experience in an AR Game: Regularized Bayesian Regression in Design-Based Research

Shane Tutwiler, University of Rhode Island
Denise M. Bressler, University of Pennsylvania

ABSTRACT

The use of null hypothesis significance testing (NHST) is ubiquitous in science education research. Passed down from an era of reduced computational power and borrowed from research paradigms where true null effects might actually exist, the prolonged use of this heuristic decision making process has resulted, in part, in the current replication crisis in the psychological and social sciences. In this paper, we demonstrate the use of an alternative Bayesian hypothesis testing paradigm that largely avoids central issues of NHST while allowing researchers to directly test hypotheses of interest and communicate the uncertainty inherent to their findings to naïve but intelligent readers. This is espeically important for researchers who use design-based research (DBR) in the service of the development and evaluation of educational technologies.

Development, Validity and Reliability of an Educational Robotics Based Technological Pedagogical Science Knowledge Self-Efficacy Scale

Hilal Yanis, Gazi University
Nejla Yürük, Academic Affiliation

ABSTRACT

Educational robotics (ER) is a developing area in literature where it was said that has a potential impact on science and technology education at all students' levels. Pre-service science teachers' (PSSTs) ER based science teaching is needed to be developed and examined by using technological pedagogical content knowledge framework (TPACK) because robots are new emerging technological tools for education. There is a need for technology (ER), pedagogy, content specific self-efficacy scale which adopts the transformative TPACK approach. In this regard, the purpose of this study was to develop technology (ER), pedagogy (contructionism) and content (science) specific ER-TPACK self-efficacy scale which adopted the transformative approach. 266 PSSTs in Turkey participated in the study. Purposeful sampling method was used. During the scale development phase, qualitative methods were used to create an item pool. During the validation phase, quantitative methods were used. As a result of the exploratory factor analysis, the ER-TPASK self-efficacy scale with 33 items was formed. According to the confirmatory factor analysis results, the first-component solution explained a total of 65.93% of the variance. The obtained results of the present study demonstrated that ER-TPASK self-efficacy scale could be a powerful scale to investigate PSSTs' ER-TPASK self-efficacy.

Strand 14: Environmental Education

Environmental and social responsibility

8:30 AM-10:00 AM, Medford

Presider: Elliott Karetny, Timber Creek High School

Action Research in a Rural Afro-Ecuadorian School and Community: El Problema de la Basura

Daniel M. Levin, University of Maryland, College Park
Carolina Napp-Avelli, University of Maryland, College Park

Carlos Vieira, The Onzole River Project
Callie Herring, Teachers2Teachers-Global
Sebastian Fernandez-Napp, University of Maryland, College Park
Jenny McGlone, Teachers2Teachers-Global
Chadd McGlone, Teachers2Teachers-Global

ABSTRACT
In this paper, we describe an action research project focused on supporting a rural Afro-Ecuadorian community along the Onzole River in learning to manage their garbage problem and its effects. We chose to pursue this problem in collaboration with local teachers as a community concern that could be supported through the school. We report here on a week-long intensive introductory period, during which we assessed local understanding of the garbage problem, provided professional development, and facilitated action in collaboration with teachers and students. We collected a variety of ethnographic data sources including: focus groups with teachers, students, and community members; observations of classrooms and community activities; recordings of professional development sessions, and samples of students' and teachers' work. We discuss findings during the week and in the two months since in the form of three themes: (1) the nature of teachers', students', and community members' understanding of the problem and concerns about it, (2) the teachers' and students' responses to the intervention, and (3) the potential for community agency and sustainability in mitigating the garbage problem

Infusing social responsibility in higher education through education for sustainable development
Heba El-deghaidy, American University in Cairo

ABSTRACT
This paper presents contributions from 41 students enrolled in the Graduate School of Education at a not-for-profit higher education institution in Egypt. The paper highlights how organisations such as higher educational institutions align their values with societal expectations through educating future generations and how such institutions need to lead societal transformation through their programmes and courses, especially in a liberal arts institution. A course on education for sustainable development (ESD) was developed and offered. The course was designed based on the sociocultural theory. The theory was reflected in all course activities and assignments through student centred collaborative activities where knowledge was shared through social cultural tools and context. The course aimed to develop students' individual social responsibility (ISR) as change agents in their local contexts. This paper illustrates the main milestones and processes through a mixed methods approach of what students went through during their enrolment in a 15-week elective course on ESD. Three instruments were developed to collect quantitative and qualitative data to answer the research questions.

Motivating High School Environmental Science Students through the Lens of Environmental Justice
Elliott J Karetny, Rowan University
Issam H. Abi-El-Mona, Rowan University

ABSTRACT
This mixed- methods study investigated high school students' dispositions towards science in society and social justice issues pre and post exposure to an environmental science class. Research questions were: (1) How do student dispositions towards science in society change as a result of studying environmental science?; (2) How do student dispositions towards environmental justice change as a result of studying environmental science?; And (3) What insights emerge from the stories told by high

school students about their experiences in Environmental Science when taught through the lens of environmental justice? Data collection and analyses involved pre and post surveys and semi-structured interviews. Findings show that participants' abstracted notion of the environment requires innovative approaches to teaching environmental science, and that students' view scientists as essential change agents in the face of environmental challenges. Findings substantiate the claim that a socioscientific and sociopolitical approach framed by environmental justice empowers and motivates students and that a STEM approach alone is insufficient to motivate high school students. Recommendations are made for transforming environmental science pedagogy and NGSS in light of a sociopolitical framework.

Youth as conservationists, altruists, inventors, and investigators: Designing for multi-faceted disciplinary identities

Heidi B. Carlone, The University Of North Carolina At Greensboro
Michelle Lovett, The University Of North Carolina At Greensboro
Alison Mercier, The University of North Carolina at Greensboro
Dearing Blankmann, The University of North Carolina at Greensboro
Ti'Era D. Worsley, University of North Carolina at Greensboro

ABSTRACT
This project engages diverse middle school youth from rural and urban communities in out-of-school learning that integrates science, engineering, and technology (STEM) to address local environmental problems related to stormwater runoff. Using youth interviews (n=52), ethnographic fieldnotes, and video analysis (n=6 case studies), we asked: What was the nature of youths' narrated meaning-making and triggered identity work? What was the nature of youths' identity-work in practice (disciplinary engagement, recognition of self/by others, and epistemic agency) during project activities?
One important design tool was a compilation of six STEM profiles that aligned with the framework, which included: conservationist, altruist, designer, tinkerer, investigator, inventor. These profiles became tools for how youth narrated their triggered STEM-linked identity work. Youth also identified the following aspects of the program as meaningful: (1) Recognition by others; (2) Increased disciplinary agency over time; (3) Making new friends; (4) New realizations that their strengths aligned with doing good STEM work. Through case studies, we linked some patterns of participation: (1) outdoor fieldwork prompted pronounced science-linked identity work; (2) many participants performed and recognized themselves as more "conservationist" than they originally thought; (3) youth responded with more investment when engaged in activities that offered opportunities for diverse epistemological engagement.

Concurrent Session 12
10:30 AM-12:00 PM

Publications Advisory Committee
Admin Symposium-NSTA's Annual Research Worth Reading Recognition
10:30 AM-12:00 PM, Eugene

NSTA's Annual Research Worth Reading Recognition

Hayat Hokayem, Texas Christian University
G. Michael Bowen, Mount Saint Vincent University
Emily G. Schoerning, Anshe Emet

Christina Siry, University Of Luxembourg

ABSTRACT
Each year, NSTA compiles a list of “Research Worth Reading” articles from affiliate journals, including JRST. Organized by the NARST publications advisory committee, this session will present the publications that have been selected this year as having important contributions for teaching practice. Join us for a discussion with this year’s recipients of the honor, as they share their work and discuss the relevance of their research to teaching practice. Facilitated by the Publications Advisory Committee, NARST Liaison to NSTA, and NSTA Representative to NARST. The selected papers for 2020 are:

Ryoo, K., & Bedell, K. (2019). Supporting linguistically diverse students' science learning with dynamic visualizations through discourse-rich practices, JRST 56, p. 270-301
Peel, A., Sadler, T. & Friedrichsen (2019). Learning natural selection through computational thinking: Unplugged design of algorithmic explanations. JRST, 56, p. 983-1007
Rouse, A. & Rouse, R. (2019) – 3rd graders’ use of writing to facilitate learning of engineering concepts. JRST, 56, 1406-1430.

Strand 1: Science Learning, Understanding and Conceptual Change
Understandings about Genetics, Evolution, and Natural Selection
10:30 AM-12:00 PM, Salmon
Presider: Nonye M. Alozie, SRI International

Fostering the Use of Key Concepts in Natural Selection
Helena Aptyka, Institute for Biology Education, University of Cologne
Victoria Hollmann, Institute for Biology Education, University of Cologne
Daniela Fiedler, IPN - Leibniz Institute for Science and Mathematics Education, Kiel, Germany
Jörg Großschedl, nstitute for Biology Education, University of Cologne

ABSTRACT
Although, evolution is a unifying theory and an overarching organizational principle in biology, it is challenging for learners to internalize it and oppose inaccurate personal truths while explaining natural selection. We conducted an empirical, quantitative study to assess whether the clarification of misconceptions and different context-related surface features in learning, influence the overall learning outcome (e.g., ACORNS). Aiming to overcome learners‘ non-reflective use of misconceptions while facilitating their use of science-driven key concept, we analysed the learning of N=197 secondary school students. For this purpose, we randomly formed four groups which differed due to the intervention units. The units were altered in terms of content-related surface features (polarities of trait change) and the level of elucidation of misconceptions. In summary, we ascertained that the context of intervention has an attributional influence on the use of key concepts. Through examinations we concluded marginally significant influences of the content-dependent intervention on the number of mentioned key concepts and misconceptions. We also achieved to replicate and corroborated current research on acceptance of evolution and the impact of prior knowledge. Our findings suggest implementing explicit elucidations of new concepts into general teaching of natural selection. An ongoing study will substantiate this approach.

Generating a Comprehensive, Context-Sensitive Framework for Evolution Cognition

Cesar Delgado, North Carolina State University
Kathryn Green, University of Georgia

ABSTRACT

Evolution education is a persistent problem area in science education. Research shows that students may hold on to religious or indigenous beliefs rather than accept scientific accounts of evolution, may develop idiosyncratic hybrid beliefs, or may hold inconsistent ideas at the same time. Existing learning theories fail to fully account for these types of knowledge. A promising framework to better conceptualize the learning of evolution is presented: collateral learning/cultural border crossing (Aikenhead & Jegede, 1999), first developed to explain science learning in non-Western cultures. We then analyze existing frameworks and typologies of evolution understanding and demonstrate how the collateral learning framework can account for the prior frameworks' categories. For religious students, or students who have other indigenous creation and speciation accounts, scientific accounts of evolution effectively are a foreign culture. If we believe in the importance of student ideas to science learning, it behooves us to carefully and respectfully consider how these ideas may form part of their cultural identity and not simply expect or demand that they abandon these entirely. Teachers need to act as "cultural brokers" to help facilitate cultural border crossing among their students, and to avoid the "cultural violence" that may result with confront-and-replace pedagogy

Improving Student Knowledge of Multifactorial Genetics Could Reduce Racial Prejudice

Brian M. Donovan, BSCS
Monica Weindling, BSCS Science Learning
Brae Salazar, BSCS Science Learning

ABSTRACT

Genetic essentialism of race is the belief that racial groups have different underlying genetic essences which cause them to differ cognitively or behaviorally. Apparently no published studies have explored if the development of multifactorial genetics knowledge produces conceptual changes in genetic essentialism. We use a quasi-experimental design (N = 227 students in 7th-12th grade) and focus groups (N = 28, 12th graders) to explore this question. Over the course of three months, we compared students who learned from a curriculum on multifactorial inheritance and genetic ancestry to students who learned from their business as usual (BAU) genetics curriculum without these topics. Relative to the BAU condition, students receiving the multifactorial genetics and ancestry curriculum grew significantly more in their knowledge of multifactorial genetics while also decreasing significantly more in their belief in genetic essentialism. Relative to the BAU condition, these students were also significantly more likely to use multifactorial explanations for a racial disparity in the United States. From a conceptual change perspective, these findings suggest that students who develop more genomics literacy through their genetics education will be more likely to conceptually change their genetic essentialist beliefs – a hypothesis we call the humane genetics education hypothesis.

Scaffolding Secondary Students' Natural Selection Transfer Through Computational Thinking

Amanda N. Peel, Northwestern University
Golnaz Arastoopour Irgens, Clemson University

ABSTRACT
Evolution is a key biological concept and natural selection is an important mechanism of evolution. However, students hold misconceptions about natural selection and struggle to explain it in different organismal contexts. This study aimed to scaffold transfer of natural selection understanding across contexts through student creation of hand-written algorithmic explanations using computational thinking (CT). Three research questions guided the project: 1. How do students' explanations of natural selection change after a CT and transfer scaffolded unit? 2. Are there contextual differences in students' explanations of natural selection after a CT scaffolded unit? 3. What are the patterns of co-occurrences in students' natural selection explanations? Students explained four natural selection scenarios as pre- and post-unit assessments: bacteria, mice, lilies, and mosquitos. Students' explanations significantly increased in natural selection content from pre- to post-unit. There were less significant differences between context in post-unit explanations than pre-unit explanations. In post-unit explanations, misconceptions occurred mostly within explanations with low (0 and 1) sequencing scores. When looking at all of the networks, mutation and initial variation did not co-occur very often, and students who sequenced natural selection correctly were more likely to include both mutation and initial variation in their explanations. Implications are discussed.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Complexity, Cognition, & the Human Experience
10:30 AM-12:00 PM, Mt Hood
Presider: Sihan Xiao, East China Normal University

Does Class Size Really Matter in a Metacognitive Biology Classroom?
Ngozika M. Mbajiorgu, Enugu State University of Science and Technology
Chinenye P Nwobodo, Enugu State University of Science and Technology
Chidinma A Ezeano, Enugu State University of Science and Technology
Conatance E Idoko, Enugu State University of Science and Technology

ABSTRACT
In this study, Senior Secondary School Class 2 students (N = 147) were placed into two groups, large class size and low class size. They were taken through an intervention for four weeks using a metacognitive strategy. Results from paired sample t test and ANCOVA analysis of test scores suggest class size had no effect on the achievement of the students. However, there was a hint that smaller class size may provide robust interactions that have the potential to ameliorate challenges faced by the academically disadvantaged thereby enhancing achievement.

Toward a Conception of Humanizing Science Learning
Takumi Sato, Virginia Tech
Daniel Birmingham, Colorado State University

ABSTRACT
In this theoretical paper, we describe the impetus for and the development a conception of humanizing science learning. Drawing from existing literature and our experiences, we present a set of humanizing science learning tenets designed to shift the role and place of science in the classroom with emphasis on humanizing the learner. The tenets recognize that: 1) Science is an active process of understanding the world around us; 2) The development of science knowledge and skills are tied to human existence both in terms of the human impact on science/world and its impact on humans; 3) Science

understandings/realities impact and mean different things to different people/communities; and 4) Science can be transformative to the communities and lives of all of us. We outline a set of humanizing approaches to science recognize that action taking is part of the learning process and supports the development of youth agency and empowerment in making sense of the world around them, identifying the issues that are most salient in their lives and then acting based on what they know and can do. We also provide concrete examples of what humanizing science learning looks like in the classroom.

Can Elementary School Students Understand The Complexity Of The Lesser Kestrel's Ecological System?
Dafna Gan, Kibbutzim College of Education and the Arts, Israel
Adiv Gal, Kibbutzim College of Education and the Arts, Israel
Orit Ben Zvi Assaraf, Ben-Gurion University Of the Negev, Israel

ABSTRACT
Understanding the complexity of natural systems is crucial to a proper understanding of what they are and how they work. This study followed environmental education program designed to introduce fifth-graders students from a highly rural community to the world of ornithology, and to the importance of maintaining the biodiversity of birds in nature. Its goal was to investigate the program's influence on the development of students' systems thinking skills in the context of the Lesser Kestrel (LK). Students' perceptions of system complexity were tracked using the repertory grid technique, which takes the form of a highly structured interview, where constructs represent the participants' interpretations of different elements and the relationships between them. The results indicate that these fifth-graders developed a significantly more complex view of the LK's ecosystem. Participation in the program developed some of the students' ability to generalize, and to identify changes in the kestrel's ecosystem that occur over time. Design elements, like longitudinal real time observations and learning about the kestrel's life-cycle while examining its interaction with its environment, were found to be important for ssystem thinking development. These cognitive tools may enable students to better cope with complex, biodiversity-related environmental issues in future.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Perceptional & Conceptual Change
10:30 AM-12:00 PM, Hawthorne/Belmont/Laurelhurst
Presider: David McKinney, University of Nevada, Las Vegas

Comparing Preservice Teachers' Perception of Learning Between Conceptual Change Inquiry Curriculum and Traditional Lecture Approaches
Lloyd M. Mataka, Lewis-Clark State College
Rex N. Taibu, Queensborough CC: City University of New York

ABSTRACT
We developed an instructional approach called Multi-Step Inquiry (MSI) which focused on students' conceptual change. We, therefore, investigate the impact of MSI on preservice teachers' (PSTs) perceptions of learning in a science classroom. Two groups, the treatment and control groups, were taught using MSI and traditional lecture respectively. We found that the treatment group had significantly more positive perceptions than the control group. We further investigated relationships between PSTs' perceptions, prior knowledge, and conceptual change. There was a significant positive relationship between PSTs perceptions and conceptual change. However, a nonsignificant negative relationship was observed between prior knowledge and conceptual change. Results from this study

strengthen the need for innovating approaches to enhancing science inquiry in classrooms.

The role of confusion in conceptual change scenarios for pre-service science teachers.

Mariya Pachman, Florida State University
Hye-Eun Chu, Macquarie University, Sydney
Lori Lockyer, University of Technology Sydney

ABSTRACT

This within-subjects experimental study investigated the effect of affective states (i.e., confusion) and question-explanation pairs containing alternative conceptions on twenty five pre-service science teachers' performance and conceptual change. Results demonstrated performance difference for easy and difficult pairs and highlighted differential influence of confusion on easy and difficult pairs. Confusion was negatively correlated to performance on easy pairs in general and specifically on the items where conceptual change was needed but conceptual restructuring didn't take place. We have also observed that high-low pattern of confusion (high after the Exposing Event and lower after evaluating Alternative Conceptions) was linked to less severe misconceptions on easy pairs. Confusion was not directly related to performance on difficult pairs on any occasions. The instructional implications and directions for future research are discussed.

The Impact of a Rich Classroom Epistemic Climate: Students' Perceptional Changes and Cognitive Growth

Yejun Bae, University of Iowa
Seohee Park, University of Iowa
Brian M. Hand, University Of Iowa

ABSTRACT

This study investigates the impact of a rich classroom epistemic climate on students' multiple competency development. As the importance of science learning is not only about building scientific knowledge but also fostering readiness to utilize intellectual resources in the real-life contexts, it is critical to examine whether students experience their cognitive and dispositional growth. Path analysis is utilized to examine how different levels of classroom epistemic climates influence students' perceptional development on learning activities and scientific reasoning skill development. The findings highlight different learning environments variously affect students' views on learning environments and reasoning skills. Students from the rich epistemic climate agreed with that they engaged in authentic dialogic interaction more and their learning experiences were valuable for future learning. Their reasoning scores was higher than those of who are in the low classroom epistemic climate.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Integration in the Elementary Curriculum

10:30 AM-12:00 PM, Meadow Lark/Douglas Fir - 3rd floor
Presider: Mark A. McDermott, University Of Iowa

Arts-Integrated Science Instruction: Exploring the impacts of instructional order effects on Earth Science learning gains

Sage Andersen, University Of California - Irvine
Joseph T. Wong, University of California, Irvine
Michael Corrigan, MDED Inc
Doug Grove, MDED Inc.

Brad Hughes, University Of California, Irvine

ABSTRACT
Proponents of arts-integration with science instruction suggest that visual and performing arts (VAPA) methods may support learning in science and may be particularly beneficial for students who lack grade-level English skills, however further research is needed to better understand how best to integrate arts and inquiry methods to maximize learning. This study analyzes data from a large-scale, multi-year research program where upper elementary teachers implemented inquiry and arts-integrated science curriculum in three content areas: Earth Science, Life Science and Physical Science. Results from Life and Physical Science showed significant increases in student learning gains when arts-methods were used to introduce a science topic prior to exploration of the content through more traditional inquiry methods. Given the many differences between each science content area, including the vocabulary and even the scientific practices expected of students, this study seeks to explore whether leading with visual and performing arts (VAPA) lessons before inquiry lessons increases student knowledge gains in Earth Science and to what extent the fidelity of curriculum implementation contributes to the impacts of ordering effects. Results from this study offer implications for how arts-integrated strategies might be best deployed in classrooms, schools, and districts to teach science.

Elementary Teachers' Conceptions of Successful Science and Literacy Integration
Leigh K. Smith, Brigham Young University
Ryan Nixon, Brigham Young University
Kendra Hall-Kenyon, Brigham Young University

ABSTRACT
Expectations of current standards are that all students develop a basic level of scientific literacy during their K-12 experience in schools (NRC, 2012). Thus, all teachers have an influential role in providing access to such knowledge and skills through classroom instruction. Elementary teachers might accomplish this through curriculum integration, an instructional strategy conceptualized in a variety of ways, that may impact teachers' ability to accurately and authentically reflect science content, ways of knowing, and practices. In this study K-5 teachers were asked to define and characterize successful integration of science and literacy. Responses were coded according to three dominant models of integration, with teachers' definitions and characterizations most often fitting the category of "recognizable subject integration," but often suggesting a disconnect between authentic integration of science and literacy. Characterizations also emphasized generic literacy instruction, such as simple content vocabulary recall or teaching reading through isolated "informational text" rather than instruction designed to help students learn to read, understand, and produce the genres of text intrinsic to science. Implications for teacher preparation and ongoing professional development designed to prepare teachers to enable children to meet new standards and actively participate in an increasingly competitive society are discussed.

Linking literacy and Science in Elementary through Project-based Learning
Joi Merritt, James Madison University
Sarah Lupo, James Madison University

ABSTRACT
Engaging students in literacy provides an opportunity for students to read for a purpose, which allows them to engage in the practice of scientists. Project-based learning provides the opportunity to learn the content, practices, and cross-cutting concepts of science, while also providing a rich context for

development of both basic and higher-level skills in language and literacy. This pilot study examined two in-service teachers and their 65 students as they engaged in a project-based unit implemented across the literacy and science blocks. Four pre-service teachers were researcher-participants in this study, co-developing the unit and observing implementation. Preliminary results indicate students were able to learn content, skills and practices from both disciplines. One in-service teacher changed perspective on the ability of students to engage in rigorus reading and writing for a purpose. Pre-service teachers gained an understanding of the research process and developed understanding of the benefits of the approach. This study suggests this approach can be used to increase science instruction and develop knowledge, skills and practices across science and literacy. It also provides insights to benefits expressed by students, pre-service and in-service teachers.

Talking and Writing Three-Dimensional Science: Examining Productive Language Demands of the NGSS Elementary Standards
Karl G. Jung, University Of South Florida

ABSTRACT
Engaging in science classrooms requires students access and use academic language characteristic of school to, among others, describe relationships, make comparisons, explain cause and effect, make hypotheses and explain procedures. This academic language requires explicit language that is rich with technical terms, and can be challenging for many students as it differs from their everyday language use. Teachers must provide instruction that supports students in using and developing this academic language, however research has shown that this remains a challenge. Elementary teachers often struggle to have clear expectations for themselves and in turn, struggle to communicate their expectations to their students. To provide this instruction and have these clear expectations teacher must have a strong understanding of the language demands students will face when engaging in science learning. To support this idea, this study examined the elementary Next Generation Science Standards to determine the productive language demands these standards place on students. Findings indicate that students will be required to utilize a wide range of language functions and forms, while producing language both verbally and in writing. Implications for science teaching and science teacher education will be discussed.

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

Inquiry-based instruction and explorative science practices

10:30 AM-12:00 PM, Salon E
Presider: Mohammed Estaiteyeh, University of Western Ontario,

Inquiry-Based Science Instruction and Student Science Achievement in PISA 2015
Cory T. Forbes, University Of Nebraska–Lincoln
Knut Neumann, Leibniz Institute for Science Education (IPN) Kiel
Anja Schiepe-Tiska, Technische Universität München TUM School of Education Zentrum für Internationale Bildungsvergleichsstudien (ZIB) e.V.

ABSTRACT
Scientific literacy is a central aim of science education. The Programme for International Student Assessment (PISA) provides a measure of scientific literacy of secondary students in 72 countries, as well as the instruction they report experiencing. PISA defines scientific literacy as “the ability to engage with

science-related issues, and with the ideas of science, as a reflective citizen" (OECD, 2016, pg. 28). Previous and recent studies on PISA science have identified important relationships between science instruction and students' scientific literacy. The purpose of this study is to further explore these relationships by using PISA 2015 data from 13 countries. We use Latent Profile Analysis (LPA) to explore how combinations of teacher-directed vs. inquiry-based instruction are associated with students' scientific literacy. Findings from our analysis indicate profiles in which the highest levels of students' scientific literacy are associated with high levels of teacher-directed instruction and moderate levels of inquiry-based instruction. The lowest levels of students' scientific inquiry are associated with high levels of inquiry-based instruction with limited teacher guidance. We discuss implications for theory and research in science education, as well as next steps in our ongoing analysis.

Matter Matters: Exploring the role of materiality in the science classroom
Rishi (Shruti) Krishnamoorthy, New York University

ABSTRACT
Recent literature grounded in a new materialist framework that recognizes the agency of matter in creating reality has challenged the non-neutral status of everyday classroom materials and instead framed them as implicated in science teaching and learning. In this paper, I build on this recent literature to look at the role of materiality in phenomena emerging within a science classroom. I argue that science concepts emerge as the consequence of co-operative intra-action between a community of materials (both human and non-human) in the classroom space. Grounded in a post-humanist and Indigenous framework, this study uses micro-analytic interaction analysis to analyze field observations and intra-views of a grade 8 biology lesson. Data analysis revealed that the act of 'seeing' a microorganism is not simple. Instead there is a very specific entanglement and intra-action with materials and humans required for the phenomena of the microorganism to emerge. It is therefore important for science teachers to consider materiality as an integral member of classroom communities.

The Progression of Preservice and In-service Science Teachers' Abilities to Teach Inquiry-based Science
Jeanette Bartley, Illinois Institute of Technology
Judith S. Lederman, Illinois Institute Of Technology

ABSTRACT
All teachers are expected to teach inquiry-based science by the National Science Education Standards, the National Association of Science Teachers, and the Next Generation Science Standards (NRC, 1996; NSTA, 2012; NGSS Lead States, 2013). The current study was a longitudinal study focused on tracking the development of four science teachers' inquiry-based instructional practices over time. The key research question was How do beginning science teachers from a preservice teacher education program that focuses specifically on inquiry-based science instruction conceptualize teaching science as inquiry as they move through preservice education, induction, and in-service? Four science teachers from the same preservice teacher education program were followed during their student teaching practicum and first four years as beginning science teachers. Findings from this study suggest that beginning science teachers' abilities to teach inquiry-based science over time are situational. It is heavily rooted in their values, beliefs, and the contexts in which they teach. The findings also suggest that regardless of a science teacher's attitudes, values and beliefs about science teaching, the context in which they teach is important and can impact their abilities and willingness to teach inquiry-based science.

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

Engaging students' interdisciplinary connections

10:30 AM-12:00 PM, Salon D

Presider: Renata P. Orofino, Universidade Federal do ABC,

Connecting ideas across courses: Relating energy, bonds, and how ATP hydrolysis can power a molecular motor

Abigail I Green, Michigan State University
Kristin N Parent, Michigan State University
Sonia M Underwood, Florida International University
Rebecca L. Matz, Michigan State University

ABSTRACT

Core chemistry ideas can be useful tools for explaining biological phenomena, but students often have difficulty understanding these core ideas within general chemistry, and connecting these ideas to a biologically relevant situation is more difficult still. This issue stems in part from a lack of explicit opportunities in relevant courses for students to practice connecting ideas across disciplines. The goal of this project is to provide a set of opportunities for students that asks them to connect their knowledge across introductory chemistry and biology courses. We are developing assessment tasks that each examine students' abilities to connect a chemistry idea with a biological phenomenon. Here, we describe the development and testing of one particular assessment task that focuses on concepts about energy in bond breaking and forming and ATP coupling. The activity was completed by 110 students in an introductory cell and molecular biology course at a large, public, research-intensive university; students were either co-enrolled or previously enrolled in general chemistry. Follow-up interviews for validity about the activity (among others) were conducted with seven students and showed that students were interpreting the questions as intended and that they valued the activities as an opportunity to connect ideas across courses.

Creating and Testing an Assessment of Interdisciplinary Connections: Entropy to Osmosis

Brianna L Martinez, Michigan State University
Kristin N Parent, Michigan State University
Sonia M Underwood, Florida International University
Rebecca L. Matz, Michigan State University

ABSTRACT

Students often struggle to make interdisciplinary connections and cite a lack of opportunity to make such connections. To address this issue, we are developing assessments in the context of three-dimensional learning that provide students explicit opportunities to make connections between chemistry concepts and biological phenomena. We first surveyed introductory biology faculty on potential areas of connection between cell and molecular biology and general chemistry and then used a modified process of evidence-centered design to draft assessment interdisciplinary tasks that incorporate scientific principles, crosscutting concepts, and disciplinary core ideas. Here, we focus on an assessment task that investigates how students incorporate the concept of entropy in explaining the biological phenomenon of osmosis across an animal cell membrane. This task was administered at two universities in both an introductory cell and molecular biology course and a second-semester general chemistry course. We found that 243 (45%) students demonstrated the ability to correctly apply the

concept of entropy in explaining the biological phenomenon of osmosis and that prior course history regarding second-semester general chemistry impacted students' ability to provide such an explanation.

When Differences Don't Divide: Graduate Students' Perceptions of Participating in an Interdisciplinary Collaboration
Katherine McCance, North Carolina State University
Margaret R. Blanchard, North Carolina State University

ABSTRACT
Interdisciplinary collaborations, which integrate knowledge, perspectives, and skills from more than one field, can generate new ways of thinking and develop solutions to problems that are beyond the scope of what a single discipline can achieve. A partnership between a Science/Engineering department and a STEM Education department is an example of an interdisciplinary collaboration. Research suggests numerous positive outcomes of collaborations between STEM and Education faculty. However, limited research exists on graduate students involved in STEM and Education collaborations. This qualitative case study seeks to address this gap in the literature by studying three graduate students involved in a Science/Engineering and STEM Education collaboration. Social Constructivism and the Communities of Practice framework guide this work. Data from interviews and participant observations were open coded and organized into five themes, using constant comparative methods of analysis. Our findings suggest the importance of participants in an interdisciplinary group to feel valued and to have a level of trust to work together. Also, Science/Engineering graduate students did not feel they sufficiently understood the STEM Education component of the project. This study highlights the importance of formatively assessing interdisciplinary collaborations and has implications for improving interdisciplinary collaborations between Science/Engineering and Education departments.

Strand 6: Science Learning in Informal Contexts
Measuring the long-term effects of informal education experiences: An interactive research symposium
10:30 AM-12:00 PM, Salon C
Discussant: Aaron Price, Museum of Science and Industry, Chicago, Neta Shaby, Oregon State University
Presider: John H. Falk, Institute for Learning Innovation

Measuring the long-term effects of informal education experiences: An interactive research symposium
John H. Falk, Institute for Learning Innovation
Adam V. Maltese, Indiana University
Lynn D. Dierking, Oregon State University
Nancy L. Staus, Oregon State University
Angela Skeeles-Worley, University Of Virginia
Neta Shaby, Oregon State University
Aaron Price, Museum of Science and Industry, Chicago
David Meier, Institute for Learning Innovation

ABSTRACT
Science education researchers in general and informal/free-choice science education researchers in particular invest their time, effort and money in trying to better understand how particular science education experience affects learners' knowledge, skill development, interest, identities and engagement. Although historically most research has focused on short-term outcomes, there is broad

consensus amongst science educators that the genuine benefits of informal experiences are not short-term but rather the long-term transformations in learners; that is, individuals sufficiently engaged that they have the interest, motivation and tools necessary to pursue a “cascade” of experiences subsequent to the initial educational event. But what research questions do we ask and how do we “measure” whether any particular educational experience catalyzes long-term cascades of additional informal (and possibly formal) experiences that can further reinforce/build upon/lead to subsequent learning? A number of major challenges limit valid and reliable research and documentation of the long-term effects of any free-choice science education experience, let alone the connection, and possible galvanizing impacts of additional science education experiences, be those informal, or school-based. These questions are the focus of this participatory symposium.

Strand 7: Pre-service Science Teacher Education

Preservice Teachers Perceptions of Engineering

10:30 AM-12:00 PM, Salon F

Presider: Heesoo Ha, Seoul National University

Looking across multiple practice-based science methods courses to Empirically Ground the Draw-An-Engineering-Teacher Test (DAETT)

Rebekah Hammack, Montana State University
Tina Vo, University of Nevada- Las Vegas

ABSTRACT

National reform documents and shifts in educational standards (NGSS, 2013) have continued to highlight the importance of engineering and engineering practices within science literacy and global citizenship. Associated with problem-solving and critical thinking, supporting students to engage in high-quality engineering opportunities as a part of formal education is the emphasis of national standards. Given this directive to reach students, education reform must also focus on in-service and preservice teachers who will have to directly meet these challenges and provide these opportunities. We sought to develop an empirically ground tool focused on engineering education. The development and use of a Draw-An-Engineering-Teacher-Test (DAETT) could provide pre and in-service teachers with the opportunity to capture their mental images and reflect on what they believe engineering does or would look like in their classrooms, allowing for the explicit discussion of issues to occur. This research documents the development and empirical ground of the DAETT. This work would be of interest to NARST members who are engaged with preservice and in-service teacher education and researchers engaged with engineering education, due to the tasks’ ability to quickly and easily assess ideas about teaching engineering and the use of performance levels to suggest next steps.

Using Epistemic Network Analysis to Explore Preservice Teachers' Connections Among Nature of Engineering Ideas

Jennifer C. Parrish, University of Northern Colorado
Jacob Pleasants, Keene State College
Joshua W. Reid, Middle Tennessee State University
Bridget K. Mulvey, Kent State University
Erin E. Peters-Burton, George Mason University

ABSTRACT
The Next Generation Science Standards place substantial emphasis on engineering as part of science education efforts. As engineering teacher education is still in the early stages, much remains to be investigated about the perspectives teachers have about the nature of engineering (NOE). The present study examined preservice elementary teachers' ideas about engineering as they completed an engineering unit and design challenge. The current study moves beyond an examination of engineering practices to consider connections preservice elementary teachers make among NOE concepts. We identified preservice elementary teachers' NOE ideas and used Epistemic Network Analysis (ENA) to explore the connections they made among engineering ideas. Results indicate that teachers generated mostly accurate statements about NOE and the connections they made among engineering ideas demonstrate movement toward more sophisticated NOE views. Using ENA to explore these connections may direct more attention to helping teachers to understand the NOE as a multidimensional construct and how engineering is related to, but different from science.

Preservice Elementary Teachers' Conceptions of Engineering and their Future Teaching Practice
Amy V. Farris, Penn State University

ABSTRACT
For preservice teachers, the position of engineering within elementary curricular standards (e.g., NGSS) can be particularly overwhelming. Elementary teacher preparation commonly includes relatively few science and mathematics courses, and rarely do any of these have explicit emphases on engineering (NRC, 2009). Adding to the dilemma, elementary education majors enrolled in STEM classes report feelings of isolation and are often unsupported to connect their view of the disciplinary content to their developing pedagogical commitments (Bergman & Morphew, 1999). In this paper, I present a preliminary analysis of data collected in an introductory engineering course for educators, taught during the Spring 2019 term. The participants are 23 pre-service teachers (PSTs). While existing self-efficacy studies provide evidence for positive effects of content courses such as this one, almost no empirical research incorporates PSTs' open-ended perspectives about their experience of these courses, and this project seeks to address that gap. I describe how the PSTs talked and wrote about the relationship between engineering and physical science with their future practice as elementary and early childhood educators (pre-kindergarten - grade 4), and focus on two students' emphasis on the engineering design process as centrally relevant to their future pedagogical practice with elementary students.

Strand 7: Pre-service Science Teacher Education

Using Principles of Engineering Design to Advance Elementary Science Teacher Preparation

10:30 AM-12:00 PM, Salon A
Discussant: Kristen Wendell, Tufts University
Presider: Brenda M. Capobianco, Purdue University

Integrating Learning of Science with Engineering Design in a Physics Course for Elementary Preservice Teachers
Sanjay Rebello, Purdue University

The Impact of Engineering Design on Student Achievement in Science
Selcen Guzey, Purdue University
Richard Lie, Purdue University

Conceptualizing modeling as a situated engineering practice within preservice teachers' learning of science and design
Richard J. Aleong, Purdue University
Robin Adams, Purdue University

Elementary preservice teachers' trajectories in learning to teach science ambitiously through engineering design
Brenda M. Capobianco, Purdue University
Jeffrey Radloff, SUNY Cortland
Kristen B. Wendell, Tufts University
Brenda M. Capobianco, Purdue University

ABSTRACT
This related paper set explores the purposeful integration of engineering design in the context of undergraduate science content and methods courses for elementary preservice teachers. Researchers from science and engineering education collectively present a myriad of evidence-based strategies, approaches, and measures designed to purposely identify and calibrate an effective approach for teaching science through engineering for elementary preservice teacher candidates. Little is known about how science faculty strategically re-align their curriculum and instruction to reflect the use of practices, such as engineering design principles, in alliance with core disciplinary ideas and cross cutting concepts. Our aim is to share research findings from our work and posit new understandings of ways to interpret how elementary preservice teachers learn science through engineering design. Implications include what we value most among our model and measures of effective elementary science teacher preparation as we enter a new era of standards and assessments in STEM education.

Strand 8: In-service Science Teacher Education
Approaches to PD to Support Science Teaching
10:30 AM-12:00 PM, Salon B
Presider: Lisa M. McDonald, Teachers College, Columbia University,

A Model for Teacher-Initiated STEM Project-Based Learning
Bryan M. Rebar, University of Oregon
Talbot Bielefeldt, Clearwater Program Evaluation
Dean Livelybrooks, University of Oregon

ABSTRACT
Project-based learning (PBL) stands out as a promising approach to integrate science, technology, engineering, and math (STEM) in order to meet the vision of the Next Generation Science Standards (NGSS). Because PBL experiences are typically teacher-initiated and thus shaped by teacher beliefs and school contexts, offering professional development (PD) that encourages teachers to utilize PBL to effectively address STEM in the vision of NGSS presents numerous challenges. Hence, this study explores the question what components of effective K-8 STEM PBL professional development are replicable? By establishing and studying a county-wide K-8 math and science professional development program involving fourteen rural and urban school districts, one institute of higher education, and a number of local industry representatives, this question is addressed with multiple measures. These measures include documentation of PD activities, teacher perspectives on the PD received, lesson plan analyses, self-reported teacher practices, student attitudes, and alumni reports. Findings point to essential

elements of PD for STEM PBL, namely, (1) design guidelines and techniques, with demonstrations of effective lessons, (2) resources (equipment, materials, and information), (3) assessment approaches for innovative designs not amenable to traditional measures, (4) community partners who can provide real-world contexts, (5) work time with colleagues.

From Doing Science to Teaching Science: Enhancing Instruction by Engaging Teachers in Extended Scientific Inquiry

Lama Jaber, Florida State University
Vesal Dini, Tufts University

ABSTRACT
In order for teachers to foster students' engagement in the practices of science, they need to have facility with those practices themselves. As such, teachers need professional development (PD) opportunities to experience the "doing of science" where they construct, assess, and refine ideas over time. Accordingly, we designed a year-long blended-online PD for science teachers with the goal of providing them opportunities to do science and then connect that experience to their teaching. Here we examine whether and how such engagement translated into teachers' instructional practices by analyzing videos of their instruction and interviews where they reflected on their PD and teaching experiences. The video analysis shows that, over time, teachers more stably took up students' contributions as scientific and built on them responsively to shape their instruction. At the same time, our analysis of teachers' interviews in tandem with in depth case studies of teachers' engagement suggest that the various curricular and institutional demands present teachers with challenges in attending to student thinking in instruction. It is therefore crucial that teacher educators productively engage teachers in their own scientific inquiry while also helping them navigate the various challenges of translating their inquiry experience to the classroom.

Motivating Change: Meeting Teachers' Needs in Science Professional Development

Brit Toven-Lindsey, California State University East Bay
Kathryn N. Hayes, California State University, East Bay
Christine L Bae, Virginia Commonwealth University
Dawn O'Connor, Alameda County Office Of Education
Jeffery Seitz, California State University, East Bay

ABSTRACT
Recent science education reforms such as the Next Generation Science Standards (NGSS) have pushed teachers to reconsider the ways they teach science to emphasize three-dimensional learning and students' development of the skills and practices used to investigate the natural world. Teacher professional development (PD) has been an important component of supporting teachers in developing the necessary science content and pedagogical skills aligned with NGSS. Research on teacher PD often focuses on design features and structures such as duration, intensity, and techniques or the specific content areas of the PD, with little attention to the conditions necessary to motivate teachers and engender a commitment to science reform efforts. Through analysis of observational and interview data, this study examines the ways that PD facilitators, including pedagogical coaches and university science faculty, interact with teachers to encourage motivation and investment in inquiry-based science teaching and learning. Informed by components of self-determination theory (SDT), this study investigates what approaches to PD meet teachers' needs by encouraging feelings of competence, relatedness and autonomy among participants.

Strand 8: In-service Science Teacher Education

Professional Development to Support Induction of New Science Teachers

10:30 AM-12:00 PM, Medford

Presider: Ryan Coker, Florida State University

Beginning Secondary Science Teachers' Contextualized and Decontexualized Inquiry Implementation: A Randomized Controlled Trial

Shannon L. Navy, Kent State University
Jennifer L. Maeng, University Of Virginia
Randy L. Bell, Oregon State University
Fatma Kaya, Kent State University

ABSTRACT

The beginning years are undeniably some of the most complex of a teacher's career. Content-specific induction programs can help teachers navigate these early years of teaching and build their instructional practices. Although there is growing interest in studying new teachers' reform-based instruction, little is known about new science teachers contextualized and decontextualized inquiry-based teaching practices. Thus, the purpose of this study was to understand the influence of a 2-year induction program on the extent to which new teachers enacted contextualized and decontextualized inquiry in their classrooms. This mixed-methods randomized controlled trial included three cohorts of treatment teachers (n=81) and control teachers (n=83). Data sources included three videotaped observations each year and field notes. Results indicated that 65-75% of both treatment and control teachers enacted decontextualized inquiry in their classrooms each year, most often by teaching science process skills and as structured inquiry lessons. In contrast, only 5-20% of treatment and control teachers implemented contextualized inquiry (in the form of problem-based learning units). These results underscore the importance of supporting new teachers in their early years to enact inquiry-based lessons that have coherence and connections to broader themes and concepts.

Impact of Beginning Career Science Teachers' Social Networks and Self-Efficacy on Retention

Meltem Alemdar, Georgia Institute Of Technology
Christopher Cappelli, Georgia Institute Of Technology
Jessica Gale, Georgia Institute Of Technology

ABSTRACT

The National Science Foundation's Robert Noyce Teacher Scholarship Program aims to increase the number of highly qualified teachers working in high needs schools. Numerous studies have indicated that teacher effectiveness and retention are related to teacher networks. Similarly, studies have shown that when teachers have a strong collaborative network, they are more likely to teach effectively and to remain in high-needs schools. The purpose of this exploratory study is to investigate the impact of beginning career science teachers' social networks and self-efficacy on their retention. Additionally, we explored the relationships among school climate, teacher personal networks, self-efficacy and retention. Results show that beginning career science teachers' likelihood of retention is moderately correlated to teachers' personal network composition such as number of people and type of people in their support group. Further, findings indicate that a teachers' network heterogeneity and their self-efficacy in classroom management are significantly associated with their likelihood of retention.

The Impact of Induction on Aspects of Culturally Responsive Instruction

Zachary Stepp, University of Florida
Julie C. Brown, University Of Florida

ABSTRACT
This study draws upon the frameworks of culturally responsive science instruction (CRSI) and culturally responsive teaching. We aimed to provide evidence that beginning secondary science teachers will exhibit greater culturally responsive instruction after completing an induction course focused on culturally responsive teaching. From 2015 to 2019, three cohorts of beginning secondary science teachers enrolled in a 3-course post-baccalaureate induction program offered at a large research university in the Midwestern US. In the summer semester after the first year of coursework, teachers met in person in a four-week course on culturally responsive science teaching. Each of 20 teachers' classroom instruction were evaluated the year before the course and the year after the course. Results showed significant increases in instruction related to family collaboration, curriculum providing diverse perspectives on content, and sociopolitical consciousness. There was a significant decrease in scaffolding and student choice in classroom activities after the course. With increasing diversity amongst our global economy, there is a growing demand to better prepare students for this change. Science teachers cannot be naïve to the diverse cultures coming into their classroom if they plan to be an effective teacher.

The Professional Learning of Secondary Science Teachers: The First-Five Years

Julie A. Luft, University of Georgia
Sissy S. Wong, University of Houston
Kathleen Hill, Pennsylvania State University

ABSTRACT
The early years of teaching are often the most difficult, yet the most important in the career of a science teacher. This qualitative study takes a longitudinal view of the early years of teaching and focuses on teachers during and post-induction programming. By following 95 secondary science teachers over a five-year period, this study reports on salient personal and professional factors that supported or constrained their development. The analysis of data revealed that the orientations of the new teachers guided how they envisioned student learning and the teaching of science, that administrative decisions can contribute to the learning of new teachers, and that new teachers accessed different professional learning opportunities over time. These results suggest that early professional development experiences provided some support for the newly hired science teachers, but not enough to establish the instructional repertoires that are envisioned by the reforms. In order to better support the development of newly hired teachers it will be important that professional learning opportunities are designed to account for their orientation towards the learning and teaching of science, have coherence with the ongoing professional learning opportunities, and contain ample opportunities to practice reform-based science practices.

Strand 8: In-service Science Teacher Education

Teacher Learning in the Physical Sciences

10:30 AM-12:00 PM, Pearl

Presider: Kelly Riedinger, Oregon State University

Analysis of AP Chemistry Teachers' Online Interaction on Facebook

Shaghayegh Fateh, MTSU
Gregory Rushton, Middle Tennessee State University
David Yaron, Carnegie Mellon University
Chinmay Kulkarni, Carnegie Mellon University

ABSTRACT

In 2013, a nationwide top-down reform in the Advanced Placement (AP) chemistry course was actualized. In accordance with the recent changes, AP chemistry teachers are expected to learn new skills, modifying their attitudes and beliefs about teaching AP chemistry. AP chemistry teachers need support to cope with the educational reform. Most present online PDs are content-centric without focusing on the social processes that are necessary for adaptation to new practices. To design proper PDs and to address teachers' needs, it is necessary to recognize the current challenges AP chemistry teachers struggle with and understand their current social interactions to see whether these interactions are leading to productive conversations about their teaching, which is needed to promote change in their practices. In this study, we focus on the "AP chemistry Teachers" Facebook group to understand teachers' needs, recurring themes, topics discussed, and the productivity of conversations. We analyzed the shared posts using the open coding method and evaluated the productivity of teachers' discussions using the interaction analysis model (IAM). We found that there were several topics that teachers discussed more frequently but that construction of knowledge in AP chemistry teachers' online conversations concentrated mostly on the lowest level (sharing/comparing of information). Implications for designing large scale online PD are considered for effectively diffusion reform practices through a teaching community.

AP Chemistry Teachers' Online Professional Learning Platform: A Design Perspective.

Samuel G. Karanja, Middle Tennessee State University
Gregory Rushton, Middle Tennessee State University - Tennessee Science, Technology, Engineering and Mathematics Education Center (TSEC)
David Yaron, Carnegie Mellon University
Chinmay Kulkarni, Carnegie Mellon University
Amanda Perez, Research Associate. Carnegie Mellon University

ABSTRACT

Research shows that professional development (PD) provides a prime medium through which in service teachers can engage in capacity building where they can gain knowledge and skills that would lead to student's achievement at a scale. Online PD provides the opportunity for teachers to connect socially, have access to novel information and deepen their content knowledge. However, several gaps exist in PD: most top-down structures are dominant in teacher's professional development, and most large-scale reforms rarely include social support for the intrinsic grassroot motivation for teachers change (Fullan 2011). Although student-student (Radel, Sarrazin, Legrain, & Wild, 2010) and student-teacher interactions haves largely been studied, (Wild, Cunningham, & Ryan, 2006) teacher-teacher interactions studies in PD is quite limited. With the new AP chemistry reforms teachers are expected to adopt new instructional approach that would help them in changing their teaching practices. These new practices can be captivated through theory of change which is a dialogue-based process expected to lead to a particular outcome. To encourage the adoption of social processes and meet teacher needs, we have conducted interviews with AP Chemistry teachers to determine the features that are necessary for

designing an online platform which influences social processes.

Factors Related to Reform in Science Teaching through Teacher Professional Development

Dennis Sunal, University Of Alabama
Cynthia Szymanski Sunal, University Of Alabama
Marilyn Maxwell Stephens, University of Alabama
Marsha Simon, University of West Georgia
Rachael L. Tawbush, The University of Alabama
Haley Harville-York, University of Alabama

ABSTRACT
This investigation centered on the long-term impact of a specialized professional development (PD) program for high school science teaching and how PD can provide support for teachers' learning. This study followed up a statewide sample of physics teachers after completion of PD where classrooms were observed multiple times over four years. The findings used a convergent parallel mixed method research design. Results of visits found that extended PD fostered significant differences over time in the way teachers structured their classrooms, conducted teaching, and engaged students. Increased classroom outcomes as evidenced in the quantitative and qualitative data were found to be related to the amount of PD experienced. The results provided a rationale for the need for continued PD focused on instructional reform among experienced physics teachers.

Strand 10: Curriculum, Evaluation, and Assessment
Dynamic Relationships between Practices and Knowledge in Science Assessment
10:30 AM-12:00 PM, Columbia
Presider: Xiaoxin Lyu, Teachers College Columbia University

Assessing Novelty and Model-based Systems Thinking in Solutions to Design Problems

Dov Dori, Technion
Rea Lavi, Technion- Israeli Institute Of Technology
Judy Yehudit Dori, Technion

ABSTRACT
Global employers seek employees who have systems thinking and creative thinking skills. Creative thinking is required for solving design problems. Novelty and usefulness are the most commonly mentioned attributes of creative thinking. We set out to investigate whether novelty and systems thinking can both be assessed based on the same conceptual model of a technological system constructed by graduate engineering student teams. Six teams of 21 graduate students constructed solution models based on a formal model-based systems engineering (MBSE) methodology. Using content analysis of the graphics and text in the models the teams created, we assessed these models for their expressed novelty and systems thinking. We used two existing rubrics, one for systems thinking and the other for novelty, both based on assessing the system's function, structure, and behavior as expressed in the models. The MBSE methodology, system design process, and assessment rubrics, presented in this paper, can be used in various project-based settings of engineering education. Both rubrics could potentially be used for formative assessment of novelty and systems thinking based on conceptual models of systems. Future studies should explore relations, if any exist, between novelty and systems thinking using larger samples, undergraduate students, and science majors.

Validating a Learning Progression for 'Mathematization' of Science

Dante Cisterna, Educational Testing Service
Hui Jin, Educational Testing Service
Shin Hyo Jeong, Educational Testing Service

ABSTRACT

We report our efforts to develop and validate a learning progression (LP) for mathematization in high-school physics and biology concepts (heat and temperature, kinetic and gravitational potential energy, carbon cycle, and relationships in ecosystems). Mathematization is defined as the capacity to abstract complex relationships among measurable variables to characterize a scientific phenomenon. Drawing on previous work for LP research (Authors, 2019), we describe three stages to develop and validate the LP for mathematization: development stage, scoring stage, and generalization stage. In each stage, several assumptions need to be fulfilled to account for the validation process. In this study, we describe the different types of evidence that were collected, the process of refinement of assessment items to measure the LP levels, and the activities designed to support a LP validity argument. This process contributes to the correct interpretation of students' progression about mathematization in science and provides the evidence needed to support our interpretations. Our research has implications for research and validation of learning progressions in science and for the study of mathematization of science.

Grade 12 Students' Conceptual Understanding of Core Ideas in Biology

Helin Semilarski, University of Tartu
Anne Laius, University Of Tartu

ABSTRACT

Biology education faces the major problem of how to educate young people in a constantly changing world. People need to be capable of making biologically justified decisions in their everyday life, especially regarding their health, e.g. vaccination, diet, type of treatment. This emphasises the need for every person to have at least basic knowledge of biological concepts and be able to apply competences to solve different everyday life problems. The goals in the next generation science standards (NGSS) reflect students' biological needs (NGSS, 2013). Conceptual understanding is needed to develop higher level abilities that would enable students to apply their knowledge. The aim of this research is to determine grade 12 students' profiles of achievement in biology. In this research 215 grade 12 students participated. The main results enabled a distinction between the students' latent profile models so as to detect the core ideas in biology and concepts that differentiated the students' conceptual understanding.

Developing an Appropriate Measurement Model for the State-level NGSS Science Assessment in Michigan.

Tamara J. Smolek, Michigan State University
Ji Zeng, Michigan Department of Education

ABSTRACT

The NGSS standards feature three-dimensional learning: Science and Engineering Practices, Crosscutting Concepts, and Disciplinary Core Ideas. Therefore, the State of Michigan science assessment has been designed such that the item clusters created based on NGSS are multi-dimensional, meaning each item on the assessment should provide evidence of students' sensemaking using two or more dimensions of the NGSS. We conducted dimensionality analyses using various approaches to investigate if we could consider the State of Michigan science assessment as unidimensional, using the 2018 field test data. We found that because the three-dimensions are considered as inseparable or fully integrated, then it is possible that the item clusters successfully testing the three-dimensional learning can be subjected to a unidimensional measurement model.

Incorporate Science Concepts in the Process of Generating Scientific Explanations

Xiaoxin Lyu, Teachers College Columbia University
Anna C. MacPherson, American Museum of Natural History

ABSTRACT

The most recent reform in science education emphasizes teaching and learning of scientific practices for all learners. Two central practices are constructing scientific explanations and arguing from evidence. Science concepts are critical to the process of generating explanations and arguments as they are necessary to connect claims and evidence in a way that increases coherence. This paper presents an analysis of middle school students' scientific explanations about ecological phenomena. Written explanations were collected from 230 students, who studied an NGSS-aligned curriculum. These responses were analyzed qualitatively to understand which concepts students leveraged in service of their explanations. The quantitative analysis highlights how scientific concepts affected students' reasoning and whether the curriculum improved their performance. Results showed that students' performance improved, on average, between the first and second modules of the curriculum. This work provides insights about how students use scientific concepts in their explanations and has implications for NGSS-aligned curriculum and assessment development and professional learning.

Strand 11: Cultural, Social, and Gender Issues

Counterspaces and Critical Considerations in University Settings

10:30 AM-12:00 PM, Salon H

Presider: Tara M. Nkrumah, Arizona State University

"Maybe on the spectrum": Physical science pedagogy and gender performativity at a major research university

Katherine Doerr

ABSTRACT

Marginalization of women is a concern in academic physical science, and when women are present they are often segregated into precarious, low status work, such as contingent faculty. Gender performativity theory, drawing on the concepts of doing and undoing gender, contends that discursive boundaries are constantly redefining gender, not as dichotomous but as fluid and performative. This paper reports on ethnographic research into the occupational lives of non-tenure track teaching faculty in a physical science department at a prestigious large public university and explores how the gender performativities of teaching faculty influence their experiences at work. My central claim is that only the gender performativities intelligible within the context of science and teaching are accepted as socially correct and can escape social sanctions. This claim is supported by an analysis of how (un)doing gender provides affordances or constraints within the workplace's culture. I show that hegemonic systems of meaning, which are entangled with regulatory schemata that produce material consequences in their occupational lives, are constituted by teaching faculty's gender performativities only in a binary sense.

Creating A Virtual Counterspace for Marginalized Communities in STEM
Ann Varnedoe, Vanderbilt
William Robinson
Monica L. Ridgeway, Vanderbilt University
Dara Naphan-Kingery
Ebony McGee

ABSTRACT
This paper explores how a virtual race-conscious and gender-conscious professional development program for Black doctoral and postdoctoral engineering and computing scholars interested in academic careers served as counterspace within this predominantly White, male field. The program paired one Black engineering faculty member with one Black social science (e.g., sociology, mathematics education, psychology) faculty member who coached 4-5 participants. We performed a thematic analysis of qualitative data to explore how the coaching program created a counterspace for Black engineering students and to identify the key elements that made said counterspace successful: transparency, trust, and affirmation.

How Biology and Physics Faculty Guide Female and URM Faculty toward Leadership, Research, and Teaching
Eugene Judson, Arizona State University
Lydia Ross, Arizona State University

ABSTRACT
The objective of this study was to determine how faculty members in higher education STEM departments guide female and traditionally underrepresented minority faculty members toward roles of leadership, research, and teaching/advising. Faculty members from biology ($n = 541$) and physics ($n = 307$) departments, representing 81 U.S. universities participated in an activity wherein they assigned five fictitious faculty members to roles of leadership (department co-chair), research, as well as teaching and advising. The activity was differently contextualized for biology and physics. Survey software randomly drove participants to one of three versions of the activity. Across the versions, the only difference was the third character: (1) Carl (male), (2) Cathy (female), and (3) Carlos (Hispanic male). Among findings, respondents were significantly more likely to recommend Cathy to a leadership role than either Carl or Carlos ($p<.05$). Cathy group respondents ($\bar{x}$Cathy = 1.86) also reported on a four-point scale significantly greater consideration of gender when making recommendations than Carlos group respondents ($\bar{x}$Carlos = 1.25) considered race/ethnicity ($p<.001$). Related, Cathy was recommended significantly less to teaching and advising roles than were Carl or Carlos. Findings are couched within the context of the concepts of minority taxation and bias correction.

Sexism, hostile work environment, and the impostor phenomenon
Devasmita Chakraverty, Indian Institute of Management Ahmedabad

ABSTRACT
Impostor phenomenon is an internal experience of intellectual phoniness that makes it difficult to accept, enjoy, or internalize success and gauge one's competence. It's relationship with sexism and hostile work environment has not been explored. This qualitative study examines how women academics in STEM and medicine who experience the impostor phenomenon and varying degrees of sexism and workplace harassment relate both of them. Qualitative data were collected through 65 one-

on-one, semi-structured phone interviews and analyzed using constructivist grounded theory and constant comparative method, leading to inductive thematic analysis. Findings indicate multiple evidences of all three forms of sexual harassment: sexual coercion, unwanted sexual attention, and gender harassment. Participants did not report these incidents due to upbringing, self-victimization, and fear of repercussion, among others. These experiences triggered impostor-feelings due to a culture of older, upper-middle-class white men in positions of power in STEM/medicine, causing alienation and mistrust. The teaching and learning of science isn't just about the subject content, but also the environment in which individuals learn and train. This necessitates examining the workplace environment in STEM/medicine that triggers impostor phenomenon among women, who are largely underrepresented (especially in higher positions) in these fields.

Strand 12: Educational Technology

Digital Tools: Research and Demonstration Showcase

10:30 AM-12:00 PM, Salon G

Presider: Denise M. Bressler, University of Pennsylvania

Digital Curation for Promoting Personalized Science Learning

Dina Tsybulsky, Technion - Israel Institute Of Technology

ABSTRACT

The article presents a research study that focused on the ways in which digital curation promotes personalized science learning and contributes to cognitive and emotional aspects of students' learning. The study was conducted in the context of K-12 education. Participants spent three months on a project that included curating a personalized digital collection. The study was conducted using a mixed-methods approach for the collection and processing of data. Findings demonstrate that digital curation provides a productive learning activity that supports personalized science learning, enabling the student to construct a personal subject ontology creation. Furthermore, findings indicate that digital curation serves to enhance the student's subject knowledge and to provide positive emotional experiences.

Examining High School Students' Scientific Practices during an Augmented Thermal Perception Lab

Shannon H. Sung, Concord Consortium
Guanhua Chen, Concord Consortium
Ji Shen, University Of Miami
Xudong Huang, Concord Consortium
Joyce Massicotte, The Concord Consortium
Changzhao Wang, University of Miami
Charles Xie, Concord Consortium
Elena Sereiviene, The Concord Consortium

ABSTRACT

Students encounter difficulties in learning science concepts that involve 'hidden' processes and phenomena that cannot be observed by the naked eye. We adopted augmented vision technology to investigate behavior related to scientific practices during the 'latent heat' lab. We chose this topic because it presented a perplexing scenario, where heat seems to come out of thin air to warm up the paper placed on a cup of tap water. Ninth-grade students (N = 112) from Northeastern US participated in the study. Students used thermal imaging application developed by the team to "see" thermal energy and to carry out investigation in the prediction-observation-explanation cycle. Their behavior was

screencast and recorded as log data by means of an infrared camera and the cellphone sensor, respectively. Semi-supervised algorithms were adopted to classify student's scientific practices based on four indexes related to the augmented thermal perception lab. Students were categorized into three groups—planner, stabilizer, and roamer. We demonstrated representative behavior and common mistakes found during active experimentation. Our ultimate goal is to scaffold the scientific practices by providing just-in-time instruction or cue on the App. The App and the automatic profiling technique have great potential. Educational implications and future studies are discussed.

Exploring middle school students' epistemological framings of a gesture-augmented computer simulation depicting thermal conduction
Nitasha Mathayas, University Of Illinois At Urbana–Champaign
Robb Lindgren, University of Illinois Urbana-Champaign

ABSTRACT
Gesture-augmented computer simulations proffer a novel category of digital technologies for science instruction that enable students to both see and physically model unobservable entities (such as molecules) of observable phenomena (such as heat transfer). Yet, to be able to engage in productive sensemaking with these simulations, students need to frame the simulation in such ways. Little is known about how students epistemologically frame computer simulations and so we explore this area by investigating how a few middle school students framed a gesture-augmented computer simulation depicting thermal conduction. We interviewed 21 middle school students to examine their interaction with the simulation and ways we supported them in their sensemaking. Through multiple case studies, we developed a preliminary scheme that identifies epistemological resources that students may use to frame the use of a gesture-augmented computer simulation. These resources span two dimensions: simulation control and simulation purpose each having their own resources within them. Through one case description, we show how a student frames the simulation passively and then shifts into an explanatory framing guided by interviewer questions. Suggestions for ways to support students and implications for future research follow.

Strand 14: Environmental Education
Traditional Ecological Knowledge (TEK): Water Stories, Sustainability, Models, and Evidence
10:30 AM-12:00 PM, Portland
Presider: Bhaskar Upadhyay, University of Minnesota

Indigenous Science Agency: Water, local knowledge, and politics
Mahesh Tharu, Jagadamba Higher Secondary School
Bhaskar Upadhyay, University of Minnesota

Indigenous Mapping: Culturally relevant, technology-enhanced teaching strategies for Indigenous learners across places and contexts
Sharon Nelson-Barber, WestEd
Jonathan Boxerman, WestEd
Matt Siberglitt, WestEd
Zanette Johnson, Intrinsic Impact Consulting
Sean O'Connor, BSCS

Indigenous education for sustainable development rooted in traditional ecological knowledge
Paichi Shein, National Sun Yat-sen University
Kai-Lung Wang, National Sun Yat-sen University
Wei-Ting Li, Taichung Municipal Sha-Lu Junior High School
Peresang Sukinarhimicc, Indigenous People Cultural Development Center

Traditional Environmental Knowledge: What can we learn from folk tales?
Rouhollah Aghasaleh, Georgia State University

Community mapping: A strategy to build knowledge of place, STEM, and culture
Pauline W. U. Chinn, University Of Hawaii At Manoa

ABSTRACT
Traditional Ecological Knowledge (TEK) or indigenous science knowledge (ISK) is an important goal of science education in an increasingly diverse global society. Teaching and learning of science through TEK has the potential to contribute to a more socially just world at the individual, the community, the national and global levels. Generally speaking, most researchers in this domain, have argued for teaching and learning science for sustainability, social change, and transformation with the goal resting on two critical ideals: deep and authentic content learning for all and supporting students in using TEK in science as a platform and tool for cognitive change. However, what teaching science with TEK looks like, how it might be accomplished, and its value in the educational system are highly contested. In other words, TEK in science education for social justice, change, and sustainability needs to be further explored in terms of curriculum, instruction, and outcomes of science education for socio-cultural change and sustainability.

Concurrent Session 13
1:00 AM-2:30 PM

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Constructing and Receiving Peer Feedback on Engineering Designs: Student Engagement and Pedagogical Supports
1:00 PM-2:30 PM, Eugene
Presider: Chelsea Joy Andrews, Tufts University

Exploring Peer-Observers' Feedback on Engineering Communication Challenges
Michelle Jordan, Arizona State University
Mia DeLaRosa, Arizona State University

"I'm like a scientist:" Critique sessions as spaces of learning and identity in urban classrooms
Rasheda Likely, Drexel University
Christopher G. Wright, Drexel University
Mikhail Miller, Drexel University

Towards a more expansive framing of feedback in elementary engineering: the social and affective benefits of asking for and giving advice
Chelsea Joy Andrews, Tufts University

Kristen B. Wendell, Tufts University

Structures of interaction in elementary engineering peer-to-peer feedback
Nicole A. Batrouny, Tufts University Center for Engineering Education and Outreach

Elementary teachers' responsiveness to supporting students' engineering design feedback
Jeffrey Radloff, Purdue University
Brenda M. Capobianco, Purdue University

ABSTRACT
Feedback is an important part of the engineering design process at all levels, from elementary to professional engineering. One approach to feedback that has been used productively throughout K-16 in many disciplines is peer feedback. Emerging research has begun to explore the promise and challenges of including peer feedback within K-8 engineering. In this session, we bring together researchers who share complementary perspectives on structures to support peer feedback in K-8 engineering. With different lenses, the papers in this session will address two related questions: (1) How does participating in constructing and receiving feedback influence students' engineering processes and progress?, and (2) What pedagogical actions make the activities of giving and receiving feedback productive? This session will advance understandings of ways students construct and respond to peer feedback on engineering design products and processes, present characterizations of different ways to structure peer feedback sessions, and inform the design of environments and materials to support peer feedback in K-8 spaces.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Inquiry Science Learning
1:00 PM-2:30 PM, Mt Hood
Presider: Zuway-R Hong, National Sun Yat-Sen University

Designing a learning sequence for inquiry: students' perspectives
David Perl Nussbaum, Weizmann Institute of Science
Edit M. Yerushalmi, Weizmann Institute of Science

ABSTRACT
Inquiry practices can be integrated into various settings that differ in terms of their constraints and hence in the scope and depth of the practices students experience. Position papers suggest implementing gradual learning sequences for inquiry practices so that students' learning experience in more constrained settings can serve them later on when engaged in advanced research projects. What is an appropriate progression of learning goals related to inquiry practices? What are the implications for the design of instruction? We examined these questions in the context of a three-year program consisting of a foundation stage followed by a long-term research project. Students were asked to identify inquiry practices they encountered during the foundation stage and evaluate their contribution to their research projects. We found that while students perceived the development of measurement and analysis skills as well as self-monitoring as useful in preparing them for future research projects, this was not the case for the practices of teamwork and communication of knowledge. We explain these findings in terms of the different meaning these practices take on when importing them from the physicist's lab into classroom norms and suggest that this impedes the cultural boundary-crossing between these two settings.

"When I do hands-on things I will remember": Authentic Inquiry Supporting Ninth Graders' Science Identities

Jennifer Tripp, University at Buffalo
Noemi Waight, University at Buffalo

ABSTRACT

This naturalistic case study examined the kinds of instructional approaches that surfaced in a ninth grade biology classroom in an urban inclusive STEM-focused high school (ISHS) and students' science identities that emerged during these approaches. Data included student interviews, field notes, and video recordings from classroom observations. After iterative cycles of in vivo, deductive, and axial coding, and triangulation of multiple data sources, findings revealed that students had opportunities for immersion in the scientific process and engaging in scientific investigation. Students considered the hands-on, novel nature of instructional approaches as most helpful for their understanding and in alignment with their interests and visions of science, which supported students' science identities. Given these findings, this study has implications for (a) providing an in-depth portrait of the curricular and pedagogical experiences of ninth graders at an ISHS from students' perspectives and (b) offering insights into the ways in which these instructional approaches can help sustain science identities among students who already have predispositions towards STEM.

Supporting Students' Autonomy throughout an Open Inquiry Process

Liron Schwartz,
Idit Adler, CREATE for STEM Institute
Michal Zion, Bar-Ilan University
Nir Madjar, Bar-Ilan University

ABSTRACT

This study explored the effect of metacognitive support on students' expression of autonomy throughout an open inquiry learning process. Based on the literature, we hypothesized this support would increase their expressions of autonomy. Two groups of junior-high students participated in a year-long inquiry-based environmental program. The experimental group (n=37) received both individual and social metacognitive support throughout the inquiry process; whereas, the control group (n=36) did not receive metacognitive support. Throughout the project, each group had an online forum that served as a means of communication between the teacher and their students. The students' online correspondences and reflections were analyzed for expressions of autonomy, according to the Self-Determination Theory. In contrast to our hypothesis, the analysis of students' online correspondences revealed that the control group demonstrated higher levels of expressions of positive autonomy than the experimental group. However, the analysis of students' reflections indicated that the experimental group expressed a better time management with the inquiry assignments and made more independent choices, than the control group. The study suggests that while metacognitive support may have hampered the students' expressions of autonomy, the support provided them with desirable difficulties that assisted them in overcoming the autonomy challenges inherent in inquiry learning.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Students & STEM Careers

1:00 PM-2:30 PM, Hawthorne/Belmont/Laurelhurst
Presider: Isha DeCoito, Western University

Stepping Into the Shoes of STEM Professionals- the Results from Longitudinal Intervention Promoting Career Awareness

Tormi Kotkas, University Of Tartu
Jack B. Holbrook, University Of Tartu
Miia Rannikmae, University Of Tartu

ABSTRACT
Lacking STEM (science, technology, engineering and mathematics) professionals is a common problem worldwide. One possible reason for this, as shown by research, is that adolescent students are not aspiring to STEM careers and this is partly linked with students' low awareness of STEM career opportunities, plus associated work characteristics. Embedding career education into science teaching at school has been suggested as a possible solution to this problem, which can help to reshape stereotypical images of STEM professions and hence attitudes towards studying science-related fields. The study aims to determine the effects of embedding STEM career education into science teaching on both students' career aspirations and on their image of STEM professions, through determination of students' perceptions of competencies requirements. In addition, students' perceptions of competencies requirements for their career aspirations are determined. The study results show that the intervention supports students' science and engineering career aspirations. Students perceptions of competencies requirements for STEM careers is not showing stereotypical characteristics. In addition, students start valuing science competencies for their future careers.

Developing an intervention course to raise middle school students science-related career awareness

Regina Soobard, University Of Tartu
Moonika Teppo, University Of Tartu
Aet Möllits, Tallinn University
Miia Rannikmae, University Of Tartu

ABSTRACT
The current study focused on developing an intervention course using career-based scenarios and a follow-up teaching-learning module for establishing student science-related career awareness. In this study, students from three schools (Ntotal=101) participated in a three year project and during this time, students were introduced to five teaching-learning modules. Before participating in the first module, students were asked to fill in a pre-questionnaire about their interest, perceived relevance, motivation and career awareness about science related careers. After the last module, students completed a post-questionnaire. After each module, students were also asked to answer an open-ended questionnaire focusing on interest, relevance, likeness, motivation, skills and career awareness. Findings indicated that students' perceptions towards science related careers were more positive after the three-year intervention period. At the same time, the students suggested they were still not ready to choose science related careers, but they agreed that they were more aware about career options and recognized that these professions were important in today's society. They also valued learning in a rich learning environment providing new experiences, from specially created teaching-learning materials,

inspiring experts visiting the class and an opportunity to work as a group and learn from each other.

How an Independent Engineering Fair Project Can Affect Student Perceptions of Science

Kelly Feille, University of Oklahoma
Annie Wildes, University of Oklahoma

ABSTRACT

Incorporating authentic engineering practices into educative experiences in elementary school has the potential to positively impact student consideration of STEM careers and increase student self-efficacy in later engineering study. Additionally as students move from primary to secondary grades, their interest in STEM topics tends to decline. To that end, teachers and researchers at Chaparral Elementary facilitated an indepdent engineering fair project to engage students in authentic practices of engineering to solve a self-identified problem with a designed or improved solution. We investigated how students' perceptions of science and engineering were affected by their engagement in the practices of engineering through a two-week long independent engineering fair project. Data sources for the study include student surveys, researcher qualitative memos, informal student interviews, and student presentations. Preliminary findings indicate that as students engaged with their independent engineering projects, their understanding of science as a tool for explaining the natural world improved and their perceptions of science and engineering and themselves as scientists and engineers was positively impacted.

The Effect of STEM Workshops on STEM Career Aspirations Amongst Middle School Students: A Longitudinal Study

Isha DeCoito, Western University
Ahmad Khanlari, OISE/UT
Stephanie L. Florence, York University

ABSTRACT

Student lack of interest in STEM is a well-known issue in Canada and elsewhere. The main question is how to increase students' level of interest in STEM disciplines and encourage them to pursue STEM education and STEM career pathways. Research suggests engaging students in hands-on STEM activities in the early years may alleviate the aforementioned trends. The research being reported is part of a larger seven-year STEM longitudinal study with a primary goal of understanding the efficacy of STEM outreach workshops, in terms of influencing student attitude and interest in STEM education over time. The mixed-methods study utilized the S-STEM survey to explore the extent to which engaging middle school students in over 540 STEM outreach workshops over three-years impacted their attitude toward and interest in STEM careers. Findings reveal a slight change in boys' and girls' career aspirations in STEM, with girls maintaining interest in medical careers, and boys in engineering and computer science. Moreover, student interest in STEM careers waned from grade 7 to grade 8. These trends will be discussed in depth and correlated with findings from the remaining S-STEM constructs.

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

Teacher instructional practices for equity in the NGSS

1:00 PM-2:30 PM, Meadow Lark/Douglas Fir - 3rd floor

Presider: Anna Maria Arias, Kennesaw State University

An Examination of Teacher Questioning Within Science and Engineering NGSS-Aligned Classrooms
Christopher Dittrick, University Of Virginia
Sarah J. Fick, University of Virginia
Anne McAlister, The University of Virginia
Jennifer Chiu, University Of Virginia
Kevin W. McElhaney, SRI International

ABSTRACT
Discourse is important for students to participate authentically in science and engineering in the classroom, and teacher questioning is an effective means of fostering authentic and effective discourse in the classroom. However, while engineering is expected to be incorporated into NGSS-aligned science classrooms, science teachers who are not comfortable with a different content area, such as engineering, may struggle with fostering productive classroom discourse in an unfamiliar content area. This study explores teacher questioning and subsequent student responses as teachers implement an NGSS-aligned project that incorporates science, engineering, and computational modeling. Following a descriptive case-study approach, preliminary analyses demonstrate that teachers include more questions in the science lesson than the engineering lesson, suggesting that teachers may feel more comfortable with science content than with engineering content. However, the teachers ask similar proportions of open- and closed-ended questions between the two lessons, suggesting that the teachers generally follow similar patterns of questioning regardless of content area. Further results will explore ways to support teachers in asking questions and responding to student thinking.

Changes in one teacher's instructional practices to support elementary students in making sense of phenomena
Cory Susanne Miller, Michigan State University
I-Chien Chen, Michigan State University
Joseph S. Krajcik, Michigan State University

ABSTRACT
The Next Generation of Science Standards supports the vision of the Framework for K-12 Science Education to engage learners in figuring out how to explain and predict phenomena. When students engage in figuring out phenomena, it also promotes their development of social and emotional learning. This mixed method case study explores one teacher's changing instructional practices in a PBL curriculum to examine the connection to the student social and emotional learning. Data was collected through surveys, classroom observations, and interviews. Results indicated that in the focal classroom where the teacher used PBL features and implemented ML-PBL curriculum, students increased their sense of ownership of their own learning. Qualitative data from observations and interviews supported those findings as the teacher developed her understanding of PBL and implemented more PBL instructional practices. We claim that when students are supported in figuring out phenomena by using strategies, like collaboration and discourse moves, their social and emotional learning also increases. With the support of their teacher, students took ownership of their learning by collaborating with their peers to explain what they have figured out and feeling comfortable making their ideas and their thinking public.

Rural Elementary Teachers' Perceptions about Incorporating Representations into their Science Teaching
Celeste Nicholas, Indiana University
Meredith Park Rogers, Indiana University
Joshua Danish, Indiana University

Cindy E. Hmelo-Silver, Indiana University
Qiu Zhong, Indiana University
Christina Stiso, Indiana University
Andrea Phillips, Indiana University
Jessica McClain, Indiana University
Alex Gerber, Indiana University

ABSTRACT
Although representations such as physical structures, graphs, and equations are foundational to science literacy, little is known about how teachers incorporate representations into science lessons to support student learning. In this case study, we draw upon a series of interviews conducted across the first year of a professional development project on representations to examine how four rural elementary teacher participants perceived: 1) what science representations are, 2) how to use them when teaching science, and 3) the factors influencing decisions about representations. Although teachers described a narrow range of forms and activities using representations across interviews, they increasingly recognized how representations supported student learning and which representations were appropriate for content. Ideas about students' abilities to create and use representations and contextual factors (e.g., time, resources) heavily influenced teachers' thinking about incorporating representations in the classroom. This study contributes to the work of constructing learning progressions for ambitious science teaching practices, providing exemplars around teaching with representations and models. Findings inform our design-based research approach, adding complexity to our definition of teacher learning and suggesting professional development opportunities.

Teaching Evolution in a 5th Grade Spanish Classroom
Lucia Vazquez-Ben, Universidade da Coruña
Anxela Bugallo-Rodriguez, Universidade da Coruña (Spain)

ABSTRACT
Biological evolution is central to comprehend our world and ourselves as human beings. However, its learning poses a real challenge when taught only in high school, as it happens in Spain. For that reason, experts from all over the world recommend starting to build this scientific model sooner, in elementary school, just as the US National Academies Press' Framework for K-12 Science Education does. Pursuing to overcome racist beliefs by learning how human skin color evolved, a sequence of tasks based on the use of scientific practices was presented to a 5th grade Spanish classroom. Like prior studies, the qualitative analysis of both the observations and the material produced by the students has shown that children at this age can deal with evolutionary core ideas. What is more, they can apply them at different levels of scale (cell, organism and ecosystem). Finally, our findings suggest that approaching social issues such as racism from a biological perspective – and emulating real science, allows for a better understanding of how Science and society relate to each other, and, above all, encourages a sense of community "where we are all different and all unique."

Strand 5: College Science Teaching and Learning (Grades 13-20)
Faculty positioning and partnerships to support teaching
1:00 PM-2:30 PM, Salon D
Presider: Anna S. Grinath, Idaho State University

A Social Network Analysis of Lecturers with Security of Employment.

Daniel Z. Grunspan, Arizona State University
Stanley M. Lo, University Of California, San Diego
Brian Sato, University Of California, Irvine
Naneh Apkarian, Western Michigan University

ABSTRACT

A large body of literature has established ways in which teaching practices can be modified to transform undergraduate STEM education. Despite this evidence, the most common form of instruction continues to be traditional lecture. Research has shown that dissemination of evidence-based teaching improvements occurs most effectively through social interaction and that informal departmental discussions drive pedagogical development. Thus, one approach to reform teaching has been to embed specialized teaching faculty into academic departments. The University of California system has a tenure-track faculty position known as the "Lecturer with Security of Employment" (LSOE), who may play an important role in disseminating evidence-based teaching practices. We examined the potential LSOEs have for reforming departmental pedagogy through informal discussions. We collected data from tenure-track faculty in 12 departments across three campuses regarding who they speak to about teaching, who they speak to about research, and who they consider influential on their teaching. Social network analyses on these data show 1) that LSOEs are particularly influential when it comes to discussions about teaching; 2) that LSOEs play an important bridging role between departments; and 3) several factors that predict whether one faculty will be influential on the teaching of another.

Partners in community college science education reform: A phenomenographic study of faculty and graduate students

Song Wang, UC San Diego
Nicole Suarez, University Of California San Diego
Stacey Brydges, University Of California San Diego
Stanley M. Lo, University Of California, San Diego

ABSTRACT

Sustainable educator professional development is an important element of science education reform nationwide. While faculty at most research universities have graduate students to rely on for instructional assistance, faculty at two-year community colleges (2YC) typically have limited access to such partnerships and collaborations. The aim of this study is to describe the variations in how 2YC faculty and graduate students experience the phenomenon of a partnership in curricular and pedagogical innovation, where partners span institutions and in some cases disciplines. Our interview data show that interactions in these partnerships range from no collaboration to collaborative engagement. Graduate students can support 2YC faculty in ways that differ from the typical role of teaching assistants at research universities, and 2YC faculty can offer graduate students mentorship in teaching while expanding their perspectives on teaching and learning through exposure to different educational contexts. These findings affirm the great (and almost untapped) potential of such teaching collaborations. Taken together with the challenges of negotiating roles, schedules, and disciplinary differences, they also inform the design of educator professional development for current and future community college faculty.

Professional development for biology instructors focusing on student thinking

Paula Lemons, University of Georgia
Sophia (Sun Kyung) Jeong, University of Georgia
Jakayla Clyburn, University of North Carolina Greensboro

ABSTRACT
College science instructors are well-versed in lecturing but not practices that uncover student thinking. Focusing on student thinking is a new skill for most college science instructors. Thus, instructors need professional development (PD) to hone their teaching practices, including the practice of revealing their students' ideas and subsequently teaching in ways that would build on those ideas. In higher education, few PD programs privilege student thinking. Most programs focus on pedagogics without considering the underlying rationale of assessing and building on students' prior knowledge. Thus, there is a need for an evidence-based, PD model with the focus on studentthinking in undergraduate science education. Computerized Analysis of Free Response (CAFR) Project (pseudonym used) is an NSF-funded, 5-year project that designed constructed-response questions and provided PD for CAFR users. The project also provided PD for college biology instructors in the form of faculty learning communities (FLCs) to help them focus on student thinking. The purposeof the study was to examine the on-going FLCs and to investigate features of FLCs that helped instructors pay attention to their student thinking. We found features of CAFR FLCs that helped biology instructors focus on students thinking in biology.

Strand 6: Science Learning in Informal Contexts

Professional Development Opportunities for Informal STEM Learning Professionals

1:00 PM-2:30 PM, Salon C
Presider: Rebecca D. Swanson, Tufts University

Professional Development Opportunities for Informal STEM Learning Professionals

Martin Storksdieck, Oregon State University
Jill K Stein, JKS Consulting
Rebecca D. Swanson, Tufts University
Lynn Uyen Tran, University Of California, Berkeley
Preeti Gupta, American Museum Of Natural History
Ardice Hartry, University Of California, Berkeley
Danielle B. Harlow, University Of California, Santa Barbara
Ron Skinner, MOXI, The Wolf Museum of Exploration + Innovation
Sinead Brien, Michigan State University
Micaela Balzer, Impression 5 Science Center

ABSTRACT
In order to engage visitors, guests, participants or audiences in positive STEM learning experiences, informal learning institutions need professionals who understand how to design for and facilitate engaging activities. Initial professional training for informal STEM educators, and subsequent ongoing professional learning create considerable challenges. There is a need for providing informal STEM educators with pathways to professionalization that guarantee high quality educators who can support successful informal STEM education. In this symposium, we propose to share research on key aspects of training and developing informal STEM learning professionals, including a framework to identify and support job competencies and knowledge gaps, results of a study on museology programs, as well as

multiple models for ongoing professional development. Our intent is to share an overview of the state of the field and current tools and programs for supporting this population of education-focused professionals, while also providing an opportunity to debate and discuss next steps in the field around standards and expectations and related opportunities for ongoing professional learning.

Strand 7: Pre-service Science Teacher Education
Preservice Teacher as Scholars and Professionals
1:00 PM-2:30 PM, Salon F
Presider: Mark A. McDermott, University Of Iowa

Creating Academic STEM Teacher Scholars: Research Experiences for Undergraduates
Jennifer A. Wilhelm, University of Kentucky
Molly Fisher, University of Kentucky

ABSTRACT
This mixed methods study investigated an education experience where preservice teachers conducted research while participating in a STEM education Research Experiences for Undergraduates program. We examined: To what degree can undergraduate research Fellows be successful with STEM education research when the research period is limited to one academic year? and What types of STEM education research projects are conducive for such a limited time setting? Survey, interviews, and self-reports conducted with the research Fellows were triangulated with their final project artifacts. Findings showed Fellows achieved positive growth in their STEM research skills and began to identify as teacher researchers. Final project artifacts included eight research papers presented at a research conference, three papers submitted for publication, and two papers accepted for publication within a one academic year timeline. This research is the first to examine the effectiveness of an academic year interdisciplinary STEM Education REU programme. REU programmes typically are offered two months (8 weeks) between Spring and Fall semesters and within only one STEM content discipline located in schools of science and engineering, as opposed to education.

Tensions in Student Teaching: Can they be productive?
Jennifer E Mesiner, University of Maryland, College Park
Daniel M. Levin, University of Maryland, College Park

ABSTRACT
The student teaching internship is the capstone of most traditional teacher preparation programs; however, placing interns into internships with quality mentors is an ongoing challenge for universities (Matsko, 2018). We take a qualitative case study approach to investigate two middle school teaching interns, Alexa (science) and Tina (math), as they navigated internships steeped in tension with their mentors. As interns are just beginning to develop their teacher professional identities, we frame our analysis through Helms' (1998) professional identity framework. We suggest the tensions with mentors made interns identities salient, reinforced them, and provided opportunities for reflection on good teaching.

Preservice Science Teachers' Epistemological Beliefs
Gunkut Mesci, Giresun University
Busra Tuncay-Yuksel, Giresun University

ABSTRACT
The purpose of the study is to investigate pre-service science teachers' epistemological beliefs and the possible causes of these beliefs. This study is theoretically framed by using Schommer's (1990) multi-dimensional epistemological beliefs model. This study is designed by using Q-method, which aims to reveal subjective structures, attitudes and perspectives from the viewpoint of the individuals. The sample of this study consists of 10 pre-service science teachers (5 female; 5 male; av.age: 21). Data are collected throughout Epistemological Beliefs Inventory (EBI). Each participant is interviewed separately, and all interviews are audio recorded for Q analysis. Within 32 items (Q sample) in the 9 ranges of intervals (from -4, to +4), all the factors are determined by centroid factor analysis in PQ-method software. According to the findings, 4 different factors are revealed and different viewpoints are stated. In this study, participants have informed understandings about 'tentativity of science', 'subjectivity', 'learning differences', and 'denying the existence of an omniscient authority'. This study differs from similar studies in in terms of the research method. It is assumed that this study with Q-method might add significant value to science education research approaches and will allow this method to be used more frequently in future studies.

Strand 8: In-service Science Teacher Education

Research Experiences for Teachers

1:00 PM-2:30 PM, Salon B

Presider: Matthew Johnson, Pennsylvania State University

Experience with Authentic Practice in an Engineering RET: Perceptions of Teachers, Mentors and Independent Observation

Kent J. Crippen, University of Florida
Gayle Nelson Evans, University of Florida
Christine Garand Scherer, University of Florida
Courtney M. Spillman, University of Florida

ABSTRACT
This study advances our design and development goal of creating a valid and reliable observation protocol for science and engineering practices (SEPs) experienced by participants working in research laboratories under the auspices of RET. This protocol offers the potential for addressing persistent questions related to participant experience by looking inside the blackbox of apprenticed professional research practice. Framed by cognitive apprenticeship and situated in an engineering RET for K-5 teachers, we independently document the SEPs which were consistently experienced across contexts and thus define a generalized teacher experience. Further, we identify key associations among the teacher's perception of their work, an independent observation and that reported by their graduate student mentors. Findings indicate that perception of involvement with any particular practice and not actual experience was a more important predictor of confidence. Perhaps most striking was the negative relationship between teacher confidence when working with mentors (r=-.242), which is similarly described by the mentors for working with teachers (r=-.356). This implies a strong need for further work and support for helping these individuals to understand each other's goals and perspectives and for finding a way to work together that generates mutual feelings of confidence and satisfaction.

K-12 teachers using authentic STEM practices in the classroom based on research immersion experiences

Matthew Johnson, Pennsylvania State University
Kathleen Hill, Pennsylvania State University

ABSTRACT

Recent reforms in STEM education suggest K-12 teachers engage their students in the practices of scientists and engineers to teach disciplinary content. However, most teachers have little experience with these activities and therefore struggle to teach in this way. Research immersion experiences (commonly referred to as RETs) have been used as professional development for years, but little is actually known about their effect in helping teachers learn about these practices and in changing their teaching style. This is the fourth study reported by the authors about a research immersion experience-based professional development program. Previous papers have focused on teacher learning during teacher workshops and the plans they develop. This study extends what we have learned by analyzing K-12 student work after participation in the curriculum developed as a part of this program. Qualitative methods were used to learn that teachers developed research projects for their students that closely mimicked their own research projects, but that the teachers had difficulty in both identifying the practices they used and that they intended for their students. It was also reported that the teachers required two years of this program to gain enough confidence to adequately implement the projects in their classes.

Personally-Relevant Critical Events as Catalysts for Shifts in Teachers' Disciplinary Understandings about Science

Shannon G. Davidson, Florida State University
Lama Jaber, Florida State University
Sherry A. Southerland, Florida State University

ABSTRACT

Current visions of science education advocate that students should engage with science in the classroom in ways that mirror the work of scientists in order to develop science proficiency. Teachers then are tasked with the complex responsibility of supporting students in understanding not only the conceptual knowledge of science, but also its disciplinary practices, norms, and epistemologies. In order for teachers to teach in such ways, they must be afforded opportunities to develop and reflect on their own disciplinary understandings of science. Research Experiences for Teachers programs, in which teachers engage in research with scientists, may be fertile contexts for the development of teachers' robust understandings about science. As such, the purpose of this naturalistic single-case study is to explore the ways in which one elementary teacher (Ava) describes shifts in her disciplinary understandings of science after participating in a six-week summer Research Experience for Teachers program. Through examination of interviews and observations, this study takes a critical event narrative analysis approach to unpack the ways in which Ava interprets certain disciplinary underpinnings of science in light of events during her research experience that to her had lasting and important impact on her understandings of science.

Strand 8: In-service Science Teacher Education

Teacher Learning in the Biological/Environmental Sciences

1:00 PM-2:30 PM, Pearl

Presider: Mohammed Estaiteyeh, University of Western Ontario

Assessment of Professional Development Supports for Teaching Bioinformatics in High School Biology: Benefits and Challenges

Susan Yoon, University of Pennsylvania
Denise M. Bressler, University of Pennsylvania
Jooeun Shim, University of Pennsylvania
Katherine Miller, University of Pennsylvania
Blanca Himes, University of Pennsylvania
Ryan Urbanowicz, University of Pennsylvania
Michael Gonzalez, University of Pennsylvania
Beth Twiss Houting, The Historical Society of Pennsylvania

ABSTRACT
Recently, science and education researchers have called for including bioinformatics in high school in order to develop bioinformatics-informed citizens and skilled bioinformatics experts. Unfortunately, there are no common standards for what or how to teach bioinformatics in high school. This study's central aim was to examine initial efforts to build professional development for teaching bioinformatics in high school biology; therefore, we created a three-week professional development workshop held in July 2019. Six US-based urban public-school teachers participated; there were three men and three women with teaching experience ranging from 2-17 years. The research question was: What are the benefits and challenges that high school biology and environmental science teachers articulate in terms of learning about and incorporating bioinformatics content and skills into their curricula? Data sources included teachers' daily reflections, a usability survey, researcher fieldnotes, and focus group interviews. Data sources were mined for common themes through a constant comparative method. Teachers articulated certain benefits: bioinformatics anchors content in real world exploration, addresses students' science self-efficacy, and enables active student participation. Teachers articulated certain challenges: bioinformatics is difficult to translate into high school curricula, requires an enhanced understanding of data literacy, and exposes the rigidity of science curricula.

From Pockets of Implementation to Embedded Practice: A Case of Teacher Learning Across Contexts

Casandra Gonzalez, Boston College
Megan McKinley-Hicks, Boston College
Mike Barnett, Boston College

ABSTRACT
This study examines the experience of a high school biology teacher, "Mary", over a year of working and learning in her classroom and in a professional development fellowship grounded in the Democratic STEM Teaching framework (DST; Basu, Calabrese Barton, & Tan, 2011). Using interview data and observations from both the classroom and the monthly professional development workshops, the authors explore the stories that Mary constructs around her understanding and implementation of DST practices. In this analysis, we examine how a teacher develops and understanding of what DST means for her and her students through the combined experiences of professional development and classroom enactment. Implications suggest that professional development that is deeply situated in classroom experiences can challenge a teacher's assumptions about her students, inspire her to build meaningful connections between student experiences and the science classroom, and thus build a more equitable and inclusive classroom culture.

Investigating Teacher Concerns About Climate Change: Identifying concerns before and after a professional development experience.

Susan Gomez Zwiep, California State University - Long Beach
Jill Grace, K12 Alliance@WestEd

ABSTRACT

This study investigates teachers' concerns about climate science before and after participation in a climate science summit, housed within a state science teachers' association annual conference. Two research questions drove the study: What concerns do K12 teachers hold about climate change and the implementation of new climate science standards into their science classrooms? What is the impact of an intensive professional learning experience on teachers concerns about climate change and teaching climate science topics? Teachers participated in six hours of program designed to get teachers "up to speed" on climate science. Conference attendees were asked to complete a survey consisting of open-ended responses related to their top three concerns about teaching climate change topics and personal concerns about climate change in general. Finding suggest that teachers teaching concerns center on their understanding of the topic, their ability to effectively teach the topic and the lack of known resources to do so. Teachers also have personal concerns related to environmental consequences of climate change and what impact they will have on humans. Findings also indicate that the targeted learning experiences shifted teachers initial concerns about personal knowledge and people's biases towards mediating the consequences and how to take action.

Teachers' challenges learning to teach coherent NGSS storylines

Jarod Kawasaki, University of California - Los Angeles
Heather F. Clark, UCLA
William A. Sandoval, University of California, Los Angeles

ABSTRACT

We report on three teachers' efforts to collaboratively design and teach an intact biology unit as a coherent storyline as part of a multiyear professional development project around the NGSS. Designing coherent storylines demands that teachers create opportunities for students to meaningfully engage in science practices in order to develop their knowledge over time, linking lessons and activities to one another and consistently framing those activities around an anchoring phenomenon. Teachers' interpretations of their design and enactment work varied, despite using collaboratively designed lessons and resources, and variations led to different manifestations of the collaboratively designed storyline, especially in terms of students' epistemic agency. This suggests that PD must attend to challenges beyond designing for coherence and find ways to help teachers develop goals and dispositions towards ceding some control within the classroom to allow students to take more responsibility for their own learning.

Strand 9: Reflective Practice

Teachers' Beliefs and Identity in Their Reflective Practices

1:00 PM-2:30 PM, Salmon

Presider: Lisa M. McDonald, Teachers College, Columbia University

Exploring Preservice Teachers' Beliefs about Effective Science Teaching through Their Collaborative Oral Reflections

Valarie L. Akerson, Indiana University
Mina Min, Appalachian State University
Fetiye Aydeniz, Indiana University

ABSTRACT

Teaching effectiveness is increasingly highlighted as an important quality in teachers, and teacher education programs have used various approaches to improve preservice teachers' teaching effectiveness. However, how preservice teachers develop their beliefs about effective science teaching and how they enact them in their field experiences have rarely been explored. To better support preservice teachers' growth, we investigate their beliefs about effective science teaching, by examining their discourses during collaborative oral reflection sessions in their early field experiences. We also highlight the possibility of collaborative oral reflection as a medium for improving reflective experiences by evaluating the quality of the preservice teachers' reflections. Theoretical and practical suggestions for teacher education and future studies are provided.

Exploring Secondary Science Teachers' Identity Development Through Reflective Practice

Preethi Titu, University Of Minnesota
Gillian H. Roehrig, University of Minnesota
Joshua A. Ellis, Florida International University

ABSTRACT

Teachers' beliefs about science teaching are established and nurtured through their own experiences as learners. While teacher beliefs have a significant impact on their classroom practices and provide a strong basis for their classroom actions, teachers' sense of identity has been shown to play a key role in their understanding of their own actions (Kelchtermans, 2005). A greater understanding of their own identities can assist new teachers as they face many of the challenges in their careers. This longitudinal qualitative study followed three beginning science teachers throughout a three-year induction period and the research design employed is an exploratory multiple case study (Yin, 2014). The study used a framework of evolving teacher identity modified from Beauchamp and Thomas (2006) to explore the teachers' identity development in terms of their classroom roles and responsibilities, the ways they think of and describe themselves as professionals, and their beliefs and practices about their classroom teaching and student learning. Data were collected from multiple sources, including classroom observations, teacher interviews, and reflective journals. The findings provide insight into how beginning teachers perceived their identities based on the three themes: (a) role as a teacher; (b) teaching practice, and (c) enhancing student learning.

Toward more agentic reflection: Analyzing beginning science teacher narratives of professional growth

Anton Puvirajah, University of Western Ontario
Michael Dias, Kennesaw State University
Laurie Brantley-Dias

ABSTRACT

Across the U.S., dimensions of reform-based teaching practice and reflective thinking of preservice teachers are being evaluated via the Teacher Performance Assessment (edTPA) currently used by over 896 Educator Preparation Programs in 41 states (SCALE, 2019). We present our efforts to expand our preservice teachers' reflective practice via a Critical Incident Reflection (CIR) protocol that affords

teacher candidates agency for choosing events of teaching practice that they deem salient for reflective analysis, while still allowing the teacher educator to direct reflection toward dimensions of reform-based practice left unexplored by edTPA. We first investigated how preservice science teacher reflections from the CIR compared to written commentaries directed by the edTPA protocol. Second, we followed these participants into their first semester as inservice science teachers to seek patterns of professional growth relating to reflections guided by both their edTPA work and CIR protocols. This research asks, "What do CIR and edTPA narratives reveal about beginning science teachers' reflective practice? How do CIR and edTPA protocols support professional growth of beginning science teachers?" Findings highlight the benefits and constraints of edTPA and the need for agentic reflection protocols to optimize professional development of science teachers.

Strand 10: Curriculum, Evaluation, and Assessment
Integration of STEM disciplines
1:00 PM-2:30 PM, Columbia
Presider: Emilie A. Siverling, Minnesota State University, Mankato

Seventh-Grade Students' Use of Heat Transfer Conceptions During an Engineering Design-Based STEM Integration Curriculum
Emilie A. Siverling, Minnesota State University, Mankato
Tamara J. Moore, Purdue University

ABSTRACT
As the integration of STEM becomes increasingly important in pre-college education, it is important to study models of STEM integration. One model, engineering design-based STEM integration, has shown promising results in terms of student science content learning. This study's purpose was to explore one student team's use of heat transfer conceptions as they participated in an engineering design-based STEM integration curriculum. A case study research design, along with procedures from qualitative content analysis, were used to identify scientific and alternative conceptions that the seventh-grade students communicated during the unit. The main result is that the students spoke and wrote about many heat transfer conceptions. For some concepts, they used scientific conceptions when other studies have shown that their peers tend to use alternative conceptions. However, the student team also created a new set of alternative conceptions in which they confused ideas from conduction and radiation as they attempted to create one set of rules about how well materials transfer heat. These results suggest that students can learn science content through design-based curricula, but they can also reveal their alternative conceptions when they need to combine and apply those conceptions to a novel context such as an engineering challenge.

Does STEM education work？- A data-driven rethinking of STEM education in China's basic education
Jing Lin, Collaborative innovation center of assessment toward basic education quality, Beijing Normal University
Richard Lamb, East Carolina University
Ping-Han Cheng, Science Education Center, National Taiwan Normal University
Yu-hsuan Chen, Science Education Center, National Taiwan Normal University
Chun-Yen Chang, Science Education Center, National Taiwan Normal University
Xiaoyu Shi

ABSTRACT
STEM education is very popular in China's basic education with diverse definitions and practices. Focusing on the unique value of STEM education in developing the core competencies of teachers and students, this study investigated the effect of STEM education on students (N=5612) and teachers (N=650) in eight schools through validated measurement instruments. The findings in the study indicated a limitation in understanding and implementing of STEM education in China. Hence, the study called a rethinking about the integration of STEM education in China and encouraged schools to engage all teachers in collaborative innovation in STEM education so as to shine the unique value of STEM education in every class to cultivate all students' core competencies for better future.

Toward integrated STEM practices: Exploring the intersections of science, engineering, and mathematical practice

Daniel Pimentel, Stanford University
Megan Selbach-Allen, Stanford University
Brandon Reynanate, Stanford university

ABSTRACT
Recent reform efforts in K-12 STEM education advocate for the integration of STEM disciplines to foster deeper connections among subjects. The Next Generation Science Standards (NGSS) takes a step in this direction by integrating the practices of science and engineering. In this study, we examined how disciplinary practices in math, science, and engineering overlap in order to gain insights into the potential affordances and limitations of using an integrated approach to STEM education. We performed a content analysis on national K-12 standards, including the NGSS and Common Core Mathematics, and coded descriptions of practices for similarities in disciplinary competencies. We identified eight practices that span the disciplines of math, science, and engineering and highlight how these might help science education researchers, science teachers, and curriculum developers think about the integration of STEM disciplines and how this integration might impact science classrooms. We also discuss potential complications that may arise when attempting to integrate STEM disciplinary practices.

A Model for Argumentation in Integrated STEM Curriculum

Carina M. Rebello, Purdue University
Yuri B. Piedrahita Uruena, Purdue University
Paul Asunda, Purdue University
Hui-Hui Wang, Purdue University

ABSTRACT
The Next Generation Science Standards (2013) performance expectation includes a tight integration of eight science and engineering practices and requires students to make deeper connections between science and engineering. One of the eight science and engineering practices emphasizes engaging in argumentation from evidence in both science and engineering contexts. An integrated STEM approach leverages teaching STEM content alongside STEM practices (Kelley & Knowles, 2016). Echoing the performance expectation that NGSS have defined, Bryan et al (2016) suggested meaningful content integration, which uses either science or mathematics as a disciplinary anchor and engineering design practices as the connecting "integrator". The development of meaningful learning experiences that foster deeper consilience among STEM disciplines and utilize argumentation to solve design problems is a major goal of integrated STEM education (Bryan, Moore, Johnson, & Roehrig, 2016; Bybee, 2013; Moore et al., 2014, NGSS 2013). However, there are disciplinary distinctions in argumentation (Bybee,

2011). We need to consider how various disciplines or communities of practice understand and implement argumentation (Grooms, Sampson, & Enderle, 2018). In this theoretical paper, we propose a model for using argumentation in integrated STEM.

Strand 10: Curriculum, Evaluation, and Assessment

What is the science curriculum of today and the future?

1:00 PM-2:30 PM, Medford

Presider: Jan H. Van Driel, University Of Melbourne

What is the science curriculum of today and the future?

Jan H. Van Driel, University Of Melbourne
Victoria Millar, University of Melbourne
Michael J. Reiss, University Of London
Dana L. Zeidler, University Of South Florida
Sami Kahn, Princeton University
Richard A. Duschl, Southern Methodist University
Jonathan Francis Osborne, Stanford Graduate School Of Education
Knut Neumann, Leibniz Institute for Science Education (IPN) Kiel
Troy Sadler, University of North Carolina at Chapel Hill
Justin Dillon, University of Exeter

ABSTRACT

Issues of what is important in a science curriculum to prepare students for a 21stcentury world are currently foregrounded in the curriculum policy documents of many countries. In the face of the knowledge explosion, new technologies and global communications and a society that questions the usefulness of science, the purpose of science education and the extent to which older forms of subject organisation need to be protected, reframed or overturned is being questioned and debated. Periodically, these kinds of significant changes occur and require that attention be paid to some of the big questions that effect science education.The field of science education has a proud history of tackling change for example Millar and Osborne's 1998 'Beyond 2000' report, Fensham's (2003) work on 'Science for All' and Roberts' (2007) Vision I and II model were all highly influential on science curriculum internationally. In order to keep this curriculum discussion active and ongoing this symposium brings together experienced scholars that have been undertaking research on curriculum in science education for many years with newer scholars in the field to take up the question of what is important in a science curriculum today?

Strand 11: Cultural, Social, and Gender Issues

Embracing Indigenous Knowledge of the African Diaspora and Tribal Communities

1:00 PM-2:30 PM, Salon H

Presider: Michael A. Ahove, Lagos State University

Culture, Context and Scientific Explanations by Biology Students: An African Case Study

Peter A. Okebukola, Africa Centre of Excellence in Innovative and Transformative STEM Education Lagos State University, Lagos, Nigeria
Tunde Owolabi, Africa Centre of Excellence in Innovative and Transformative STEM Education Lagos State University, Lagos, Nigeria
Michael A. Ahove, Africa Centre of Excellence in Innovative and Transformative STEM Education Lagos

State University, Lagos, Nigeria
Akeem Akintoye, Africa Centre of Excellence in Innovative and Transformative STEM Education Lagos State University, Lagos, Nigeria

ABSTRACT

The goal of this study was to examine how socio-cultural factors impact Nigerian students' explanation of biological phenomena. Additionally, it seeks to find out how such factors can be harnessed for improving performance of students on tasks requiring explanations in science. The design was a case study implemented in two schools over a 9-month period involving qualitative and quantitative data-gathering techniques. The topics covered were diversity of organisms, Mendelian genetics, ecology, plant and animal physiology, and biotechnology. During the course of the study, a total of 3,924 scripts containing answers to questions demanding explanation of biological phenomena were graded. A random sample of students was interviewed every two weeks to seek in-depth information on why they offered the explanation to the biological phenomenon in their answers. The teachers noted the socio-cultural attributes colouring each explanation. Follow-up reviews by the research team aggregated five socio-cultural attributes of the explanations namely language, habitat, religious orientation, socio-economic status and gender. The study suggests that science teachers should look beyond traditional variables in the quest to explain students' performance.

For the Next Seven Generations: The Hopes and Needs of Pottawatomi Parents for Their Children

Jared Tenbrink, University of Michigan

ABSTRACT

In order to better understand the science education learning experiences of Native American children, a needs analysis with the community members of a tribe in the Great Lakes region of the United States. Through focus groups and interviews the author, who is also a member, spoke with members of the tribe to hear their hopes and desires for their children. Members voices are used to lift up their hopes and needs of The Tribe and share the voice and perspective of an unheard from community. Three themes emerged from the conversations, protecting tribal culture, science for tribal sovereignty, and STEM career options for the youth. Each area is explored and connected to science education in order to inform future research. Through focusing on the members hopes and desires for the future this work is an example of decolonizing research (Smith, 2013) and adds to the field of science identity and education.

The Pull from Both Sides: Analyzing the Bicultural Experiences of 1.5-Generation Nigerian-American Female STEM Students

David M. Sparks, University Of Texas At Arlington

ABSTRACT

Three 1.5-generation, Nigerian-American, female students attending a diverse urban university participated in face-to-face interviews and a focus group about their experiences as science, technology, engineering, and mathematics (STEM) majors. Centered on the intersectionality of their race, gender, and bicultural identities, qualitative analyses revealed the role of their African heritage on their success in STEM, impressions of race and racism in the United States, similarities and differences between African immigrant and African American students, and importance they place on peers, mentors, faculty, and role models matching their unique intersectional identities. Future research should explore the applicability of intersectionality to the choice of, and success in, STEM fields for populations of bicultural

students with similar racial and ethnic experiences.

U.S. and Ghana: Exploring Cross-Cultural Perspectives on Engagement in Science for Underrepresented Students

Tara M. Nkrumah, Arizona State University

ABSTRACT

This study's purpose was to explore science engagement and in/equity through science educators' narratives of servant leadership at both the K-12 and higher education levels in the United States and Ghana. The research question was: How have participants become and led others to become engaged in science? I took an arts-based approach using drawings and autobiographical data to initiate and create métissages focused on becoming engaged in science education. The findings were that: (1) Participants helped marginalized students understand the culture of science through pedagogical strategies that connected self and science; (2) Participants recognized and countered systemic forms of oppression for students who are marginalized in science education through outreach in STEM; and (3) Participants offset disengagement in science among underserved groups through meaningful relationships and presented non-dominant examples of scientific inquiry. I discuss their implications for professional development and provide recommendations for future research concerning leadership/followership aimed at promoting science equity.

Strand 12: Educational Technology

Teaching with Technology

1:00 PM-2:30 PM, Salon G

Presider: Jonah B. Firestone, Washington State University Tri-Cities,

Co-Teaching with Digital Games: Cultivating Effective Teacher-Game Partnerships in Science Classrooms

Karen Mutch-Jones, TERC
Santiago Gasca, TERC
Danielle C. Boulden, North Carolina State University
Eric N. Wiebe, North Carolina State University

ABSTRACT

Research shows that teaching with digital games supports students' science learning (Clark, Tanner-Smith, Killingsworth, 2016), however, simply adding games to classrooms does not necessarily improve learning—teacher instruction with games remains essential (Vega, 2013). This exploratory study investigated high school science teachers' instructional roles with an immersive genetics game, featuring dragons that need to be saved from extinction, and highlighting the role of proteins in genetics. Teacher data were collected via implementation and daily feedback surveys, classroom observations, and interviews. Teacher plans and student artifacts augmented the data set. Results suggest that when digital game features, like a teacher dashboard and an intelligent tutoring system offering progressive levels of hints, are responsive to teacher concerns about student productivity and learning, teachers establish game partnerships. Co-teaching with the game enabled educators in the study to use game-oriented instructional strategies, which addressed the needs of a range of learners. Moreover, when teachers felt the game encouraged student investigation and addressed conceptual learning goals, they utilized class-wide gaming experiences and language to enhance learning activities that followed or surrounded the game. Thus, while immersive games can be powerful, these results suggest a more nuanced role for teachers to maximize their impact.

Examining Professional Development Designed to Support Geospatial Inquiry
Brooke A. Whitworth, University of Mississippi
Eric Nolan, Northern Arizona University
Lori Rubino-Hare, Northern Arizona University
Mark Manone, Northern Arizona University
Nena Bloom, Northern Arizona University

ABSTRACT
The current study scaled-up proven PD by providing Facilitation Academies which taught facilitators to provide Teacher Workshops (TWs) to secondary STEM educators. The purpose was to identify how TWs prepared teachers to implement geospatial inquiry lessons, provided them with geospatial technology (GST) performance skills, and prepared them for teaching a lesson with students. Surveys, GST assessments, lessons, observations, and artifacts were analyzed using a-priori coding and descriptive and correlational statistics. Participants included secondary STEM teachers who attended Power of Data Teacher Workshops. Results suggest what happens when an educational innovation that works in one setting is implemented by trained facilitators in other contexts. The study identifies effective design principles that support the uptake of new practices in the classroom as well as identifying issues teachers struggle with when trying to implement geospatial inquiry lessons.

Understanding the Perceived Usefulness of Mobile Technology in Physics Learning: A Pedagogical Perspective
Lehong Shi, East Lansing
Xiaoming Zhai, Michigan State University

ABSTRACT
This study investigates how users' pedagogical role impacts the perceived usefulness of mobile technology, the use frequency, and student physics learning achievement. We examined how 803 high-school freshmen used 15 specific functions of tablets in physics learning. Based on pedagogical role students and teachers play, the 15 functions were classified into three categories: five for student-led, five for teacher-led, and five for collaborative functions. Results indicate that collaborative functions were higher perceived as useful and were more frequently used as compared to both teacher-led and student-led functions. Student-led functions were perceived as least useful and were least frequently used. The perceived usefulness and use frequency significantly predict the student's physics achievement by both the pedagogical category and gender.

Strand 14: Environmental Education
Citizen engagement: Between attitudes and behavior
1:00 PM-2:30 PM, Portland
Presider: Dani Lin Hunter, Colorado State University

Adult Food Waste and the Effectiveness of a Video Intervention on Increasing Intended Pro-Environmental Behaviors
Kathleen A. Fadigan, Pennsylvania State University
Zelnnetta Clark, Pennsylvania State University
Jaclyn Bolton, Pennsylvania State University
Amira Spikes, Pennsylvania State University

Visalakshi Vaithianathan, Pennsylvania State University

ABSTRACT
The purpose of this online study is to investigate adults' knowledge, attitudes, and behaviors related to food waste and the effectiveness of a video intervention designed to increase pro-environmental behaviors. The study explored personal food waste habits, understanding and use of date labels, and views on dumpster diving. A sample of 445 participants completed an online survey that included a 33-question pre-test, viewing a 4-minute educational video intervention, and a 13-question post test. Results revealed that despite relatively positive perceptions of food waste behaviors, the participants held misconceptions regarding date labels and held negative connotations regarding dumpster diving. However, after the video intervention, participants significantly improved their knowledge and intended food waste reduction behaviors.

Citizen Scientist or Citizen Technician: How we talk about volunteer tasks and who's benefiting
Danielle Lin Hunter, Colorado State University
Gregory Newman, Colorado State University
Meena M. Balgopal, Colorado State University

ABSTRACT
Citizen science is often described as benefiting the scientific community, society, the environment, and volunteers. While participation in citizen science can increase volunteer scientific literacy, recent research suggests that this does not occur in projects where volunteers only collect data. In this study we conducted a content analysis of project descriptions (n = 152) along with content on hyperlinked websites (n = 23) found on CitSci.org, a citizen science user platform. We analyzed volunteer tasks according to cognitive order as defined by Bloom's Taxonomy. We also considered who was benefiting from the tasks volunteers performed. We found that most projects described volunteers as performing low order tasks and described benefits to citizen science projects. Our analysis suggests that the way project managers describe citizen science engages volunteers in limited participation in the scientific process, potentially limiting volunteer agency to enact change in their own local environments. Further, our findings suggest that there may be a missed opportunity to increase volunteer scientific literacy.

Environmental attitudes/values and concern - two constructs with one aim
Gregor Torkar, Professor, Univ of Lubljana
Franz X. Bogner, University Of Bayreuth

ABSTRACT
Attitudes, values and concerns are frequent empirical measures to monitor individual preferences of adolescents. We relied on both and applied two established scales (2 Major Environmental Value Model [2-MEV] and Environmental Motives Scale [EMS]) to a Slovenian sample of 804 middle and high school students. The main objective of our study was to extract the factor structure in order to explore the relationship between both scales. The results show that altruistic, biospheric and egoistic environmental concerns correlate strongly positively with preservation of nature, but negatively and less strongly but still significantly with utilization of nature. We conclude that raising awareness of egoistic environmental concern may be as important as altruistic and/or biospheric concern for the development of environmental values and attitudes. Consequences and recommendations for designing and completing educational programs are discussed.

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