GLOCALization and Sustainability of Science Education Research and Practice

11130 Sunrise Valley Drive | Suite 350 | Reston, Virginia 20191 | USA
www.narst.org | info@narst.org | 703.234.4138 | fax 703.435.4390

NARST
A worldwide organization for improving science teaching and learning through research

Pre-Conference Workshop #1: Equity and Ethics Committee (Free – 90 participants max)
Glocalization and Sustainability of Science Education Research and Practice
8:00am – 11:45am, Hyatt Lone Star F
Organizers:
Enrique Lopez
Nam-Hwa Kang
Tasneem Anwar
Senetta Bancroft
Phillip Boda
Tamra-Kay Alisa Francis
Deniz Saribas
Azam Saiqa
Sheron Mark, University of Louisville
ABSTRACT:
Globalization and sustainability in science education has increasingly received attention among educators, researchers, and policymakers. Cultivating a scientifically literate citizenry has been tied to the concepts of globalization and sustainability. As highlighted in NARST's conference theme description, glocalization represents a dual perspective which combines the ideals of globalization with the importance of localization. Pre-conference workshop participants will engage in constructive and meaningful dialogue with leading science education scholars about the influences of glocalization on educators, researchers, and policymakers' efforts to build and sustain scientific literacy within local contexts for a global citizenry. Through an equity and ethics lens, this workshop will pay special attention to understanding the concepts of glocalization, sustainability, and scientific literacy; exploring how these concepts have been used within science education practice, research, and policy; and critiquing the benefits and limitations glocalization and sustainability offer the science education community. Dialogue between and among workshop participants and leading science education scholars will be facilitated through round table and panel discussions.

Pre-Conference Workshop #2: Research Committee (Free – 42 participants max)
Critical Youth Participatory Research in Science Education
8:00am – 11:45am, Hyatt Republican ABC
Presenters:
Angela Calabrese Barton
Edna Tan
Jrene Rahm
Christina Nazar
Kathleen Schenkel
Daniel Birmingham
Tara O'Neill
Takumi Sato
Day Greenberg
ABSTRACT:
New methodological approaches are needed to tackle the persistent inequalities in science education experienced predominantly by youth from historically marginalized communities (e.g. youth of color, youth from lower economic backgrounds). This pre-conference workshop will focus on facilitating dialog, challenging existing frameworks, and building capacity towards the use of critically-oriented youth participatory research methodologies in science education. A central goal of this pre-conference workshop is to critically explore, interrogate and expand what we know about youth participatory research practices in science education and what we need to know in order to advance its role in the field. While youth participatory action research [YPAR is one of many forms of youth participatory methodologies] has been established within the field of educational research more broadly, youth participatory research methodologies are both underutilized and undertheorized in our field. Given this challenge, this pre-conference workshop will bring together diverse perspectives in our discussants who already do YPAR work in science education. Our goal with the workshop is to discuss: 1) principles of critical youth participatory research in science education; 2) the roles that youth can play in the research process, and 3) how their participation transforms the broader structures and outcomes of educational research (e.g. how researchers and teachers understand and seek to solve enduring problems of practice, emergent tensions across race, class gender and education levels, etc.) 4) what can participants do in their own work to be inclusive of youth participatory methodological approaches.

Pre-Conference Workshop #3: Research Committee (Free – 30 participants max)
Dialogical Argumentation as a Pedagogic and Mediating Tool for Harmonizing Students' Lifeworld with School Science
8:00am – 11:45am, Hyatt Presidio ABC
Presenters:
Meshach Ogunniyi
Femi Otulaja
Christopher Diwu

Keith-Roy Langenhoven
Cynthia Fakudze
ABSTRACT:
A review of the extant literature in science education reveals that science is an enterprise whose epistemic structure is underpinned by an array of arguments and counter-arguments. In the same vein, though well-known is that indigenous knowledge systems (IKS) is underpinned by a variety of arguments and counter-arguments of different forms-drama, songs, proverbs, idioms, graphics, dance, storytelling, etc. The literature further shows that the deployment of argumentation as an instructional tool does indeed enhance students' awareness of and understanding of the Nature of Science (NOS) and nature of IKS (NOIKS) which in turn contributes to their development of critical thinking and decision-making skills. Traditional argumentation frameworks used in science education are largely premised on the inductive-deductive and mechanistic scientific worldview. This implies that argumentation frameworks that do not conform to the scientific worldview are readily dismissed and normally disregarded. On the other hand, argumentation used in traditional or indigenous education embraces both logical and non-logical (not necessarily illogical) culturally embedded arguments.

Pre-Conference Workshop #4: Research Committee (Free – 40 participants max)
Developing a Competitive Educational Research Proposal for the US National Science Foundation (NSF) Division of Research on Learning
8:00am – 11:45am, Hyatt Travis AB
Presenters:
Michael Ford
ABSTRACT:
This workshop aids researchers in submitting proposals to the NSF Division of Research on Learning in Formal and Informal Environments (DRL). The workshop focuses on: 1) funding programs and opportunities in DRL; 2) characteristics and significant changes in DRL's major programs; 3) NSF's proposal review process and merit review criteria; 4) characteristics of competitive proposals; and 5) common weaknesses of proposals.

Pre-Conference Workshop #5: Research Committee (Free – 50 participants max)
Designing Adequately Powered Effectiveness Trials for Science Intervention Studies
8:00am – 11:45am, Hyatt Bowie ABC
Presenters:
Joe Taylor
Jessaca Spybrook
Susan Kowalski
ABSTRACT:
Researchers often wish to be able to make causal links between an intervention and student or teacher outcomes. When researchers wish to make causal claims, they generally use either quasiexperimental or experimental designs comparing a treatment group to a comparison group. But how many participants does a researcher need for a given study? Accurately estimating the number of participants to detect an effect has huge implications for both the cost of a study and the responsible use of researcher dollars (often provided by taxpayers). Too many participants result in excessive costs, and too few participants can result in a failure to detect an important intervention effect. Accurately estimating the number of participants for a study is a critical and a sophisticated decision-making process, particularly when studying interventions in classroom contexts where students are nested within teacher, and teachers are nested within schools. To conduct an accurate power analysis, researchers need to know how to find and use a variety of power analysis parameters, including but not limited to an estimate of the expected effect size, an estimate of how similar clusters of participants are to one another (for example, how similar one class of students is to another class), and how much a researcher can expect to explain differences between groups using covariates such as pretest scores and demographic characteristics. To make power analyses even more difficult, these power analysis parameters that researchers need to use are just now becoming available for science outcomes through a combination of meta-analyses of effect sizes and statistical analyses of large state data sets. In this workshop, we will focus on how to design and calculate the statistical power for effectiveness studies of science interventions. The workshop will focus on a variety of effectiveness trial designs, including those with and without nesting at multiple levels. The principles learned will apply to both experiments and quasi-experiments and therefore cover a wide variety of effectiveness trial designs. Participants will learn how to use the Optimal Design Plus Software, a freely available and user-friendly program for calculating the power for effectiveness trials. We will also share our recent research findings related to empirical estimates of design parameters specifically for effectiveness trials related to science outcomes. The workshop will combine short presentations of information with multiple opportunities for discussion and hands-on practice using the Optimal Design Plus Software. The target audience for this workshop is science education researchers interested in planning and conducting effectiveness trials. It will be of particular interest to any researcher who would like to submit a proposal of an effectiveness trial for federal funding. Funding agencies are demanding increasingly sophisticated arguments that any effectiveness trial will include a sufficient number of participants in order to detect a treatment effect, should that effect exist. Participants will leave the workshop with the skills to make those nuanced arguments.

Pre-Conference Workshop #6: Publications Advisory Committee (Free – 30 participants max)
Scholarly Writing for Early Career Researchers

8:00am – 11:45am, Hyatt Crockett AB
Presenters:
Julie Luft
Bryan Brown
Zahra Hazari
Vanessa Kind
Danusa Munford
Marissa Rollnick
Bhaskar Upadhyay
ABSTRACT:
An important part of a researcher's professional life is sharing scholarly work with colleagues. For many researchers, the first place to share work is at a conference; thus, learning to write conference papers is an essential part of entering the field. Conference papers can then lead to publications. For the new researcher, learning how to conceptualize, write, and revise research for publication can be challenging. To support some of NARST's newest members, the Publications Advisory Committee is sponsoring a pre-conference workshop on scholarly writing. The workshop will consist of panel and small group discussions about topics such as making choices about writing projects, selecting an appropriate journal, finding time to write, and responding to reviews. There will also be an opportunity for each participant to receive feedback (not detailed) on a piece of writing. This workshop is designed for early career researchers (e.g., postdoctoral researchers, pre-tenure faculty members, researchers in non-tenure-granting institutions who received their doctoral degrees in the past 6 years) who are interested in exploring the process of writing for publication. Participants will have the option to submit a sample of pre-publication writing (e.g., a NARST conference paper) by April 3 for mentor and peer feedback. In addition, each participant will be asked to read and respond to at least two of their colleagues' papers prior to the workshop. This preparation will form the basis for small group discussions at the workshop. Please take these pre-workshop activities into consideration when deciding whether to register. If you have questions about whether this workshop is appropriate for you, please contact Alicia Alonzo (alonzo@msu.edu) before registering.

Pre-Conference Workshop #7: A NARST Board Sponsored Workshop (Free – 90 participants max)
Making NARST Transparent: Organization, Roles and Responsibilities
10:30am – 11:45am, Hyatt Lone Star E
Organizers:
Tali Tal
Katherine McNeill
Barbara Crawford
Selina Bartels
John Tillotson
ABSTRACT:
The goal of this workshop is to focus on how NARST works and how to advance your career through service to NARST. You can make a difference in our NARST community, by being involved as an active participant in the leadership of NARST. We will provide an overview of the structure and organization of NARST, as well as the various opportunities. This will include describing the responsibilities of different roles, such as Board Members, committee chairs and committee members. The audience will include new Board Members, committee chairs and members, as well as those new to NARST, including graduate students, international members, early career members and those looking to be more involved in NARST. After an initial overview, we will break into groups to discuss some of these possibilities and responsibilities in more depth for different roles. We would also like your input on how to make these opportunities more visible for the larger NARST community.

Plenary Session #1
Strong Performers and Successful Reformers in Science Education: Lessons from the World
1:00pm – 2:30pm, Hyatt Texas Ballroom A, B, and C
Presider: Mei-Hung Chiu, National Taiwan Normal University
Presenter:
Andreas Schleicher
Director for Education and Skills, Special Advisor on Education Policy to the Secretary-General, Organization for Economic Co-operation and Development (OECD)
ABSTRACT:
Equipping citizens with the science knowledge and skills necessary to achieve their full potential, contribute to an increasingly interconnected world, and ultimately convert better skills into better lives is a central preoccupation of policy makers around the world. Over the past decade, the OECD Programme for International Student Assessment, PISA, has become the world's premier yardstick for evaluating the quality, equity and efficiency of school systems. The latest PISA assessment in 2015 focused on science, a discipline that plays an increasing role in our economic and social lives. Science is not only the domain of scientists. In the context of

massive information flows and rapid change, everyone now needs to be able to "think like a scientist": to be able to weigh evidence and come to a conclusion; to understand that scientific "truth" may change over time, as new discoveries are made, and as humans develop a greater understanding of natural forces and of technology's capacities and limitations. The last time science was the focus of PISA was in 2006. Since then, science and technology have advanced tremendously. The smartphone was invented and became ubiquitous. Social media, cloud-based services, robotics and machine learning have transformed our economic and social life. New possibilities of gene sequencing and genome editing, synthetic biology, bio-printing or regenerative medicine and brain interfaces are changing life itself. Against this backdrop, and the fact that expenditure per primary and secondary student rose by almost 20% across OECD countries over this period, it is disappointing that, for the majority of countries with comparable data, science performance in PISA remained virtually unchanged since 2006. But some countries showed substantial improvement in the science performance of their 15-year-olds, including high-performing education systems, such as Singapore and Macao (China), and low-performing ones, such as Peru and Colombia. The presentation will review the progress achieved in science learning in different parts of the world, identify some of the characteristics of high-performing education systems, and discuss effective policies and practices that are associated with success.

Concurrent Session #1
2:40pm – 4:10pm

Publications Advisory Committee Sponsored Symposium
How to Get Your Research Published in Science Education Journals
2:40pm-4:10pm, Hyatt Lone Star D
Presider: Alicia C. Alonzo, Michigan State University
Representatives of Publishers:
Ian White, Routledge
Eric Piper, Wiley
Bernadette Ohmer, Springer
Journal Editors:
Fouad Abd-El-Khalick, Journal of Research in Science Teaching
Dana L. Zeidler, Journal of Research in Science Teaching
Sherry A. Southerland, Science Education
John Settlage, Science Education
Jan H. Van Driel, International Journal of Science Education
Ross Nehm, CBE Life Science Education
Catherine Milne, Cultural Studies in Science Education
Christina Siry, Cultural Studies in Science Education
Michael Mueller, Cultural Studies in Science Education
Alan Reid, Environmental Education Research
Sue Dale Tunnicliffe, Journal of Biological Education
Lisa Benson, Journal of Engineering Education
Jan van Aalst, Journal of the Learning Sciences
Susan Yoon, Journal of the Learning Sciences
Kent Crippen, Journal of Science Education and Technology
Norm G. Lederman, Journal of Science Teacher Education
Judith S. Lederman, Journal of Science Teacher Education
Gregory J. Kelly, Science and Education
Shrikrishna Singh, Routledge/Taylor & Francis
David Boyt, Routledge/Taylor & Francis
ABSTRACT:
Are you wondering how to turn your NARST conference paper into a published article? At this session, a panel of publishers and journal editors will share tips and strategies for getting your research published in science education journals. The panelists will address issues such as: choosing the right journal, preparing your manuscript, responding to reviews, and maximizing your article's readership. Following the panel, journal editors and representatives of the publishers will be available in a roundtable format to discuss the particular requirements of their journals and to provide individual guidance to authors.

Strand 1: Science Learning, Understanding and Conceptual Change
Admin Symposium: Quality STEM Education for All: The Role of Science Education in Supporting Migrant and Refugee Children

2:40pm-4:10pm, Hyatt Bowie ABC
Presenters:
Ibrahim Delen, Usak University
Knut Neumann, Leibniz Institute for Science Education, Kiel
Ingrid M. Sanchez-Tapia, UNICEF
Joseph S. Krajcik, Michigan State University
ABSTRACT:
Sixty-five million children around the world are running from conflict, poverty and extreme weather, looking for a better life and a place to call home. To cite a few examples: between 2014 and 2016 almost ninety-thousand unaccompanied minors from El Salvador, Guatemala and Honduras have been detained in Mexico or the U.S.A border while running away from violence. Moreover, 2.6 million Syrian children are no longer in school and more than 2.5 million are living as refugees in neighboring countries. They are among the most vulnerable people on earth, and they too have the right to quality education. Typically, refugee and migrant children receive education in emergencies, focused on restoring normalcy to their lives through psychosocial support, recreation kits, and basic learning materials that emphasize numeracy and literacy. Very rarely is science education part of the education response for children in emergencies. We believe that science education is integral to quality education, and because children in emergencies have the same rights as any other children to education of good quality, excluding science education from their experience is problematic. Once migrant children reach nations such as Turkey, Germany and the United States, they often face language barriers and academic expectations that make their adaptation even more stressful. During this symposium we will discuss the role of science education in coming up with solutions that help migrant and refugee children experience the highest possible quality of learning, supporting them in succeeding in a new culture and a new school system.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Symposium: Epistemic Agency as a Members' Experience
2:40pm-4:10pm, Hyatt Travis AB
Presider: Christina Krist, University of Maryland College Park
Discussant: Brian Reiser, Northwestern University
Presenters:
Christina Krist, University of Maryland College Park
Danielle T. Keifert, Exploratorium
Déana A. Scipio, TERC
Anna M. Phillips, Tufts University
Jessica Watkins, Tufts University
David Hammer, Tufts University
Brian J. Reiser, Northwestern University
ABSTRACT:
One of the key challenges of the "practice turn" in science education is supporting learners' agentive participation in science and engineering knowledge-building practices. However, the current characterizations in the literature of learners participating with epistemic agency vary greatly in terms of what counts as "having" epistemic agency and who decides what counts. We argue that, because meaningful science inquiry is itself a complex constellation of practices, epistemic agency may take on different forms and purposes throughout the inquiry process. This symposium seeks to empirically articulate such variations in what epistemic agency looks like in science inquiry. We bring together studies of learners participating in science inquiry across ages (pre-school to college) and settings (home, school, and informal environments) to work towards developing a members-centered, ethnographically- and interactionally-grounded characterization of epistemic agency for science inquiry. We argue that such a definition is critical for how we recognize, design for, and support learners' epistemic agency.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Assessing Young Learner's Science Thinking
2:40pm-4:10pm, Hyatt Bonham B
Presider: Sarah J. Carrier, North Carolina State University

Identifying the Ingredients of STEM in Unexpected Places: Early Childhood Cooking Activities
Todd Milford, University of Victoria
Christine D. Tippett, University of Ottawa
ABSTRACT:
There is limited information on STEM instruction at the early childhood level. What is available are suggestions that science instruction for young children should be play-based, build on prior knowledge, highlight concepts that are developmentally appropriate, and include a scaffolded inquiry approach (e.g., Trundle & Saçkes, 2012). Children's early science (and by extension, STEM) experiences should be hands-on and allow them to experiment and explore with everyday materials in meaningful ways; these

types of experiences are related to later academic and social success. In this presentation, we highlight a pre-existing cooking program for Pre-Kindergarten (Pre-K) students and describe opportunities the program provides for STEM integration. Using a classroom observation protocol, we identified 23 out of 48 indicators of early childhood STEM, with another 6 indicators being supported by the teacher. Evidence from this small case study supports the inclusion of STEM in early childhood education, and suggests that STEM can be nurtured in less traditional contexts such as cooking. The young children in this study were participating in activities that are likely to promote STEM learning: engaging in questioning, process skills, and scientific and engineering practices.

Investigating Upper Elementary Students' Conceptual Knowledge of Magnetism through Writing
Osman Aksit, North Carolina State University
Alonzo B. Alexander, North Carolina State University
Eric N. Wiebe, North Carolina State University
Bradford Mott, North Carolina State University
James C. Lester, North Carolina State University
ABSTRACT:
This study investigated how fourth grade students' conceptual understanding of key magnetism concepts compared before and after they completed an inquiry-based learning unit in a digital science notebook. Data sources included 173 students' written explanations to six driving questions in the learning unit. A constant comparative method of analysis was employed to identify the emerging patterns of students' conceptual resources and mental models. A Wilcoxon signed-rank test was conducted for each FQ to determine whether there is a significant difference in the conceptual levels between the students' initial and final responses to the driving questions. The findings indicated that students were facile at acquiring categorical knowledge about what kinds of materials were or were not magnets. However, they had difficulty developing a conceptual understanding of the particulate nature of properties underlying these materials. The findings also showed that students were more successful at developing notions of force at a distance via magnetic fields, while the polar nature of magnetism and how it varied with distance was more challenging. This study contributes to the literature of what elementary students are capable of learning about magnetic phenomena and the particulate nature of matter.

Learning a System of Practices of Science through Energy: A Fourth-grade Case Study
Roger G. Tobin, Tufts University
Sara J. Lacy, TERC
Sally Crissman, TERC
Nick Haddad, TERC
Nathaniel J.S. Brown, Boston College
Gulsah Gurkan, Boston College
Courtney Castle, Boston College
ABSTRACT:
We report a case study in which a small group of fourth grade students analyze the energy flow when a solar panel is used to power an electric motor that drives a propeller. In the course of the activity the students engage in nearly all of the science practices designated in the Next Generation Science Standards. The students had previously completed a sequence of 10 activities in which they used science practices as they learned about energy, but they did not receive separate lessons on the practices. This case study demonstrates that elementary school students can effectively and un-self-consciously recruit a system of science practices to analyze a real-world situation if they are provided with a rich and engaging activity; appropriate and versatile language and representational tools; and ample experience in using those tools to analyze phenomena of increasing complexity, both individually and as a group, led by a teacher who is well prepared to support their efforts. It also suggests that the study of energy offers a promising context for student use of science practices, especially the practice of developing and using models.

The Effect of Hands-on Activities on Elementary Science Learning: A Critical Literature Review
J. Steve Oliver, University of Georgia
Lu Wang, University of Georgia
ABSTRACT:
In this proposal, we examine the research about the influence of hands-on activities science content learning in formal elementary science instruction. Hands-on activities have been regarded as an effective way of science teaching until the Pine et al. (2006) study showed that hands-on curricula didn't improve students' scientific inquiry abilities or scores on conceptual assessments. Since then more research which showed no or even negative effects of hands-on curricula has been published. In this paper, we examine the research from both sides of the argument. We examine factors related to greater student achievement as well as those which are not related with greater accomplishment. We also investigate the factors that influence the effectiveness of hands-on activities. Our results show that even though most of the studies investigated students' conceptual knowledge improvement during instruction featuring hands-on activities, the achievement benefit to students is often more evident during instruction focused on scientific practices and affective parameters. Also, among the factors that influence the efficacy of hands-on activities, the design of the activities themselves is most important. Hands-on activities that are related to positive science conceptual achievement are characterized by lack of undue complexity and supported by appropriate PD for the teachers.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Special Topics in Science Teaching and Learning
2:40pm-4:10pm, Hyatt Crockett AB
Presider: Noh Heejin, Korea National University of Education

Assessing Teacher and Student Effects of the Research Goes to School Project
Alex T. Madsen, Purdue University
Gabriela C. Weaver, University of Massachusetts, Amherst
ABSTRACT:
Nanoscience is a rapidly growing field with the United States government budgeting over one billion dollars for nano-based research. There are also over 1,600 products currently on the market using nanotechnology such as sunscreen and clothing. However, nano-based content has not been integrated into K-12 curriculum or state standards. The Research Goes to School (RGS) project used a summer professional development workshop to bring nanoscience content and project-based learning (PBL) into the high school curriculum. PBL was chosen since it is a teaching strategy that mimics the way science is done by addressing authentic problems in science using real scientific processes. High school STEM teachers from around Indiana developed a nano-based PBL unit to implement in their classrooms that aligned with state and national standards. This study focused on teachers' pedagogical content knowledge while implementing novel subject matter and a new teaching strategy. Student learning gains on the nanoscience-related material was also assessed. A content exam was used to assess student learning gains while interviews and the content representational tool was used to analyze each teacher's pedagogical content knowledge (PCK). This study provides a glimpse into a potential relationship between PCK and student learning gains.

Fifth Grade Students' Model-based Argumentation and Informal Reasoning about Landslides
Bahadir Namdar, Recep Tayyip Erdogan University
Aysegul Demir, Recep Tayyip Erdogan University
ABSTRACT:
The purpose of this study was to investigate 5th grade students' model-based argumentation and informal reasoning about landslide subject. The participants were 17 5th grade students from a suburban northeastern Turkish public middle school. The participants were engaged in 7 session modeling activities on landslide subject. Data was collected through students' semi-structured interviews and their lab notebooks. Results indicated that after modeling activities students' informal reasoning included rationalistic and emotive reasoning patterns. After modeling-based activities students who used intuitive reasoning in their initial arguments abandoned these patterns and increased their argumentation qualities, and the students used information from their models as warrants, backings, and data in their arguments about landslide subject.

Impact of the STEM Career Graph on the Perceived Inclusion of STEM Domains in Careers
Daniel L. Dickerson, East Carolina University
Kristine L. Callis-Duehl, East Carolina University
Joi P. Walker, East Carolina University
Steven F. Wolf, East Carolina University
William J. McConnell, Virginia Wesleyan College
Petros Katsioloudis, Old Dominion University
Stephen R. Burgin, University of Arkansas
ABSTRACT:
The focus of this study was to examine the impact of a National Science Foundation (NSF) funded intervention (i.e. STEM Career Graph activity) designed to increase secondary students' understandings of how STEM domains are related to traditional (e.g. marine biologist) and non-traditional (e.g. chef) STEM career options. There are many programs currently underway that are engaged in efforts to enhance students' attitudes, interest and understandings regarding Science, Technology, Engineering and Mathematics (STEM) content and careers (National Science and Technology Council, 2011). The need to address the STEM career pipeline has continued to gain momentum in recent years, particularly among National Science Foundation funded efforts both within and outside of the Education Directorate. We employed a mixed-methods, holistic, multiple-case design that compared two cases (Yin, 2009). The implications for the STEM education community involve: 1) dissemination and application of a novel activity and instrument to address STEM career awareness and education; 2) providing further supporting evidence the use of common STEM terms in instruments are likely being operationalized in ways that are not consistent with the community's definitions; and 3) interventions such as this one may help students find relevance in STEM subjects after discovering the connections between their chosen careers and STEM domains.

Students' Longitudinal NOS Views 4-5 Years after an Explicit/Reflective Middle School Science Course
Jesse L. Wilcox, Drake University
Jerrid W. Kruse, Drake University

Randi E Lines, Drake University
Ehren Whigham, Drake University
ABSTRACT:
While the nature of science (NOS) continues to be an important goal of science education and much is known about how to effectively teach NOS, few studies have investigated the longitudinal NOS understanding of students who have been effectively taught NOS during their K-12 educational experiences. This study investigated the NOS views of 22 students 4-5 years after an 8th grade science course in which NOS was explicitly and reflectively taught. A mixed methods approach was used to evaluate participants' views on: theory-laden NOS, tentative NOS, laws vs. theories, cultural influence on science, creative NOS, existence of a single scientific method, collaborative NOS, methodological naturalism, the role of time in science, and discovery vs. invention. The results indicate most students made large gains in developing views aligned with NOS literature during their 8th grade year. While, in general, participant views regressed four to five years later, most participants maintained remnants of the NOS learning they developed during their 8th grade year and maintained views that were more aligned to NOS literature than they held before their 8th grade year.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Symposium: Biology Education Research (BER) at NARST – Opporunitites for All
2:40pm-4:10pm, Hyatt Crockett CD
Presider: Abdi M. Warfa, University of Minnesota
Presenters:
Abdi M. Warfa, University of Minnesota
Sehoya Cotner, University of Minnesota
Sara E. Brownell, Arizona State University
Stephanie Gardner, Purdue University
Maurina L. Aranda, Purdue University
Cara Gormally, Gallaudet University
Seth K. Thompson, University of Minnesota
Cissy Ballen, Cornell University
Katelyn Cooper, Arizona State University
Lucas M. Jeno, University of Bergen
ABSTRACT:
"Opportunities for All" is an invited symposium convened to build bridges between the biology education research (BER) and the NARST scholarly communities. BER is part of the growing field of Discipline-Based Education Research (DBER) in which scientists and science educators conduct educational research within their disciplinary contexts (e.g., chemistry, physics, geology). Established and emerging BER scholars in this symposium will share varying perspectives on biology teaching and learning at the college level under the general theme of promoting opportunities for all biology students. Specific topics include discussion of: STEM equity, access, and gender issues both in the US and internationally; interweaving learning progressions; novice-expert competencies in graphical representations of biological data; and the role of inquiry and affective domain in increasing STEM diversity. These studies and the participation of BER researchers in this conference promise to create a dynamic and interconnected community of researchers working to impact science teaching and learning for all students, in all environments.

Strand 7: Pre-service Science Teacher Education
Symposium: Developing Trajectories for Ambitious and Equitable Elementary Science Teaching: Exploring Novices' Knowledge, Beliefs, and Practices
2:40pm-4:10pm, Hyatt Presidio ABC
Discussant: Mandy Biggers, Pennslyvania State University
Presenters:
Elizabeth A. Davis, University of Michigan
Annemarie Palincsar, University of Michigan
Amber S. Bismack, University of Michigan
Benjamin L. Tupper, University of Michigan
Jacqueline F. Handley, University of Michigan
Mandy Biggers, Pennslyvania State University
ABSTRACT:
Scientific sensemaking in elementary education is important for students' learning, yet is atypical in elementary classrooms. The current project seeks to develop trajectories of novice elementary teachers' knowledge, beliefs, and practices for engaging in ambitious and equitable science teaching that would support scientific sensemaking. The longitudinal study investigates two waves of preservice teachers in an undergraduate elementary teacher education program. Among the 78 total participants, 20 were selected as focal preservice teachers. Data sources included videorecords, lesson plans, and reflections from preservice teachers' practice, as well as interviews with preservice teachers and their mentor teachers. The findings suggest that preservice teachers drew on a range of

domains of content knowledge for teaching, including extensive use of common content knowledge integrating science content and practice. They saw students as sensemakers, but struggled to support students in shifting their science ideas. They used a range of high-leverage science teaching practices, including special practices that support access to equitable science learning opportunities, and demonstrated varying levels of proficiency in these practices. The session will present these findings and begin discussion of the development of initial trajectories that begin to capture the complexity of novice teachers' development of knowledge, beliefs, and practice over time.

Strand 8: In-service Science Teacher Education
Argumentation
2:40pm-4:10pm, Hyatt Bonham D
Presider: Margaret R. Blanchard, North Carolina State University

Supporting Self-Regulated Learning Strategies to Improve Teacher Outcomes in a Scientific Argumentation Professional Development Experience
Erin E. Peters-Burton, George Mason University
Jordan Goffena, George Mason University
Mike Briscoe, George Mason University
ABSTRACT:
The purpose of this multiple case study was to examine self-regulated learning processes (SRL) and learning outcomes of three teachers in a professional development (PD) on argumentation in science to assess the interaction between types of processes employed by teachers and corresponding learning outcomes. Additionally, the study was conducted to determine the extent to which SRL prompts may have guided real-time change in the PD instruction. Three heterogeneous cases of secondary science teachers were selected for variation in teacher self-efficacy for the PD, the type of schools in which the teacher taught, and experiences with argumentation in science. The results of the case studies showed that teachers who had appropriate SRL strategies, such as the ability to set advantageous goals, self-monitor appropriately, evaluate their learning accurately, use strategies that worked well in future endeavors, and adapt those that did not work well, created lesson plans that engaged students in argumentation at higher levels of a validated learning progression. It was found that SRL prompts were a useful tool to instruct individuals to improve their understanding of argumentation in science and helped the instructor alter instruction by assessing learner strategies.

Teacher Changes While Implementing Argument-based Inquiry and Their Impact on Student Critical Thinking Skills
Soonhye Park, North Carolina State University
Jee Kyung Suh, University of Iowa
Yejun Bae, The University of Iowa
Brian M. Hand, University of Iowa
ABSTRACT:
This study reports the second year results of a 3-year research project that aims to: 1) identify changes that teachers make as they become more capable to implement the SWH approach, and 2) link their changes to student science achievement and critical thinking skills. This study employed a mix-methods research design involving 24 secondary science teachers in U.S. Data sources include three types of teacher survey, classroom observations, teacher interviews, and student scores on Cornell critical thinking test and on a statewide standardized test. Results indicate that teachers sped up growth in epistemic orientations during the second year whereas their changes in epistemic orientation occurred very slowly in the first year. Their SWH implementation levels gradually improved built off of their progress made during the first year. Students improved critical thinking skills by 4.51 points growth over the second year while they improved by 1.63 points growth over the first year. As teachers made more improvement in epistemic orientations, their implementation levels and student critical thinking skill scores were higher. All of the results highlight that teacher changes in orientations and practices necessary to adopt a new approach are possible with sustained and purposefully designed professional support.

The Impact of Implementing and Refining an Argumentation Instructional Model on Science Teachers' Beliefs
Patrick J. Enderle, Georgia State University
Ozden Sengul, Georgia State University
Yotah Koulagna, GSU
Jonathon Grooms, George Washington University
Victor D. Sampson, University of Texas, Austin
ABSTRACT:
Scientific argumentation has garnered much attention over the past decades, both from scholarly communities and policymakers. The emerging emphasis on scientific practices, including argumentation, in US national and state level documents have led to a dramatic increase in the development of resources to support science teachers' instruction that emphasizes these practices. Further, a variety of approaches have been developed to support science teachers in deepening their understanding and ability with practices such as argumentation. One goal of effective professional development is to help teachers' shift their beliefs about teaching and learning into

closer alignment to the fundamental perspectives used to construct such materials. Collaborative design of instructional materials and models, involving classroom teachers directly in several cycles of development, implementation, and revision, has been posited to be a powerful model for engendering such changes. The study presented in this paper describes patterns of change and stability in a group of four teachers' beliefs about science teaching and learning as they participated in several years of collaborative design activities involving an instructional model and resources emphasizing scientific argumentation. Although relatively stable, the patterns of change noted do provide insight for future iterations of collaborative design activities.

Theory and Pedagogy of Argumentation in Science Education: Science Teachers' Instructional Practices
Yasemin Ozdem-Yilmaz, Gaziosmanpasa University
Jale Cakiroglu, Middle East Technical University
Hamide Ertepinar, Istanbul Aydin University
ABSTRACT:
Argumentation has been a prominent concern in science education research and a common goal in science curriculum in many countries over the past decade. With reference to this goal, science teachers are expected to involve students in dialogues and be guides in students' spoken or written argumentation. Consequently, teachers' understanding and pedagogical practices regarding argumentation gain importance due to their impact on how they incorporate this scientific practice into their science classrooms. In this study, we investigated the instructional strategies adopted by science teachers for their argumentation-based science teaching. Participants were 1 elementary science teacher, 2 chemistry teachers, and 4 graduate students, who have a background in science education. Data sources included the participants' video-recorded classroom practices, audio-recorded reflections, post-interviews, and participants' written materials. The findings revealed three typologies of instructional strategies towards argumentation. They are named as argumentation specific pedagogical knowledge, meta-level pedagogical knowledge specific to argumentation, and meta-strategic knowledge specific to argumentation. Based on the findings, it was concluded that through a cycle of reflective practice, the teachers adapted and developed instructional strategies to promote argumentation in their teaching practice. Moreover, the study provided a detailed coding framework for the exploration of science teachers' instructional practices.

Strand 8: In-service Science Teacher Education
Symposium: Exploring Examples of Organizational Sensemaking as Educators Shift Teaching Practices to Align to NGSS
2:40pm-4:10pm, Hyatt Republic ABC
Discussant: Carrie Allen, SRI International
Presenters:
Sara C. Heredia, The University of North Carolina, Greensboro
Tammy L. Cook-Endres, Exploratorium
Therese Arsenault, Gateway Middle School
Clarissa Deverel, Gale Ranch Middle School
Carrie D. Allen, SRI International
ABSTRACT:
In this symposium, we extend the concept of organizational sensemaking to think about how different science educators across different contexts modified their current teaching practices to align to NGSS. Four members of a professional community of science teachers housed in a science museum will present different outcomes of organizational sensemaking as each worked to align their current practice to the new vision for science education in NGSS. We demonstrate how each of us modified already established practices within our institutions to incorporate aspects of three-dimensional learning. We will share challenges and successes we had in this process with implications for the field in thinking about how current professional learning activities can be modified to support implementation of NGSS.

Strand 11: Cultural, Social, and Gender Issues
Symposium: A Spectrum of Youth Participation in Research Across Sites/Uses: Toward Critical Equity Frameworks
2:40pm-4:10pm, Hyatt Travis CD
Presider: Heidi Ballard, University of California Davis
Presenters:
Angela Calabrese Barton, Michigan State University
Edna Tan, University of North Carolina, Greensboro
Takumi Sato, Virginia Polytechnic Institute and State University
Daniel Birmingham, Colorado State University
Tara B. O'Neill, University of Hawaii
Myunghwan Shin, California State University, Fresno
Kathleen A. Schenkel, Michigan State University
Day W. Greenberg, Michigan State University
Christina Restrepo Nazar, Michigan State University

Heidi Ballard, University of California, Davis
ABSTRACT:
Youth participatory methodologies are well-positioned to facilitate dialogue and insight between researchers and those most affected by educational research -- students. However youth participatory research methods are underutilized and undertheorized in science education research. Given this challenge, we examine different ways and methods of involving youth as stakeholders, experts, and voices of change in education through a variety of participatory research methodologies. Bringing together studies from three community-based STEM-oriented makerspace projects, two curriculum-focused projects, and one after-school club dedicated to green energy and social justice, we examine the similarities and differences of youth participation in research across each of these sites. These six projects encompass a wide range of theoretical frameworks informing their use of participatory methodologies, and an equally diverse scope of research focuses. We share themes common across these projects to discuss principles of participatory research, the roles that youth play in the research process, and finally, the ways in which their unique participation affects their interaction with science and the research itself. This symposium will promote a conversation that foregrounds youth voice by including youth presenters, and invites those both experienced and new to participatory research to contribute to the growing knowledge and use of such methods.

Strand 12: Educational Technology
New Frontiers for Learning
2:40pm-4:10pm, Hyatt Bonham C
Presider: Muhsin Menekse, Purdue University

Project-Based MOOCs As Means For Enhancing Knowledge Construction And Motivation To Learn
Miri Barak, Technion, Technion-Israel Institute of Technology
Abeer Watted, Technion-Israel Institute of Technology
ABSTRACT:
Literature on massive open online courses (MOOCs) shows an ongoing debate about their educational value. Some studies indicated high positive satisfaction among learners; while others point out difficulties. The increasing number of research on MOOCs focus mainly on dropout rates, engagement patterns, and large-group learning. However, little attention has been devoted to the study of small-group, multicultural, project-based learning and its impact on students' outcomes. Applying the mixed methods approach, this study aimed at examining the role of project-based MOOCs in the process of knowledge construction and motivation to learn of scientists and engineers worldwide. The study compares between three research groups: English MOOCers, Arabic MOOCers, and university students. Findings indicated positive attitudes towards learning, especially with relation to gaining work experience in the field of nanotechnology, among all groups. Differences were indicated in participants' assertions about their familiarity gain with the nanotechnology subject matter, with an advantage for the English MOOCer. Findings also indicated that in an online project-based setting, MOOC participants were mostly driven by a desire to establish connections with peers, whereas university students were mostly driven by their desire to advance their personal knowledge.

EMAC Framework: Disseminating Research Findings through Blogs, Podcasts, and Online Videos
Eun Ah Lee, University of Texas, Dallas
Matthew J. Brown, University of Texas, Dallas
ABSTRACT:
The citizen-expert relationship plays an important role in civic science literacy. Non-expert citizens should learn how to form communities capable of science-inflected civic debate, in other words, the informed public sphere, while experts should learn how to listen to the public. As new, emerging media take the place of the traditional media in public engagement, science education needs to pay attention to communication between citizens and experts through new emerging media platforms. In this study, we explored a way that experts can disseminate their research to a broad audience using experimental publishing on emerging media platforms. The case presented here is an engineering ethics education research with three groups of stakeholders: academic communities, engineering faculties and students, and the general public. Traditional publications of research findings only addressed academic communities, thus we tried online experimental publishing to access a broader audience including engineering community as well as the general public. We developed the EMAC (Emerging Media and Communication) framework and used it to present the research findings. The EMAC framework emphasizes narrative across media, so we used storytelling through text, image, sound, and moving images to disseminate these research findings in the form of blogs, podcasts, and online videos.

Second-year Results from a Randomized Trial to Evaluate Glocalized Online Science Units for Middle School
Fatima Terrazas Arellanes, University of Oregon
Emily Walden, University of Oregon
Lisa Strycker, University of Oregon
Alejandro J. Gallard, Georgia Southern University
ABSTRACT:

Glocalization in science education—the intersection of local context with a shared international community—has come at a time when the U.S. education system is at a crossroads. In science, the U.S. has established Next Generation Science Standards, a rigorous set of expectations for the learning and application of science concepts. Students who struggle—including English language learners and students with learning disabilities—are required to meet these standards alongside their peers. New developments in educational technology, properly applied, can offer supports to help struggling students excel in science. The purpose of this paper is to update results presented at NARST 2015 by presenting second-year results from a 3-year project to implement standards-based online science units in middle schools. These units incorporate glocalization by focusing on local and global science content and facilitating collaboration. The units were designed to help all students, especially English learners and students with learning disabilities, receive equal access to science learning. Results indicated significant gains in science content knowledge from pre- to post-implementation among treatment group students who studied with the units, relative to controls. This study documents one approach for supporting a healthy and successful local science learning environment that is also globally relevant.

Strand 13: History, Philosophy, and Sociology of Science
Diversity in Nature of Science, Scientific Inquiry and History and Philosophy of Science
2:40pm-4:10pm, Hyatt Lone Star F
Presider: Allison Antink-Meyer, Illinois State University

Beyond the Myth of the "Scientific Method": A Case Study of Pre-service Chemistry Teachers' Understanding of the Diversity of Scientific Methods
Sibel Erduran, University of Oxford, UK
Ebru Kaya, Bogazici University
ABSTRACT:
Teaching and learning of the “scientific method” has been advocated in international curricula for decades. For example, the Next Generation Science Standards (NGSS Lead States., 2013) refers to “scientific investigations use a variety of methods”. Although the significance of the inclusion of the scientific method in science curricula has been recognised, there has been concern about the conventional way in which the scientific method is depicted in science textbooks and teaching as a linear and stepwise process. We present an empirical study based on a funded project conducted in a pre-service science teacher education programme in Europe where the diversity of scientific methods was highlighted. The study focuses on an in-depth case study of 4 pre-service chemistry teachers who were engaged in a task where they debated alternative ways of thinking about scientific methods. Data collected included (a) individual interviews before and after the implementation of the task, (b) poster representations during the task, and (c) lesson plans developed by the group. The data were analyzed using qualitative methodology. The results illustrate a more nuanced depiction of scientific methods by pre-service teachers. The paper illustrates how the diversity of scientific methods can be integrated into teacher education provision.

Complex Changes: Visualizing Teacher's Accurate Understanding and Misconceptions Regarding Scientific Inquiry and Nature of Science
Yue Li, Miami University
Sarah B. Woodruff, Miami University
ABSTRACT:
This study describes and explains patterns of change of in-service teachers’ accurate understanding and misconceptions regarding scientific inquiry (SI) and nature of science (NOS) after participating in professional development (PD) funded by the National Science Foundation Mathematics Science Partnership program. This study reported findings from teachers’ responses to a Likert-type scale questionnaire prior to beginning professional development and after one, two, three, and four years of participation. Instead of reverse coding misconception items and including them in the same factors, teachers’ pre- and post-scores for accurate understandings (y-axis) and naïve understandings (x-axis) were plotted to determine the relationship between accurate and naïve conceptions and to represent change in teachers’ understandings over time. This study provides a visually direct way to examine teachers’ progression in understanding of SI and NOS and to identify and locate their transitional stages. Measurement methods that account for changes in both accurate and naïve understandings allow researchers to study how teachers’ trajectories in developing accurate understanding of SI and NOS influence their teaching practices and student learning. These findings also are fundamental to understanding how teachers’ learning of accurate conceptions of SI and NOS is impacted by PD programs so that teacher PD can be improved.

Understanding and Acceptance of the Theory of Evolution Among Tibetan Buddhist Monastics
Tenzin Sonam, University of Arizona
ABSTRACT:
This study explores the understanding and acceptance of the theory of evolution among Tibetan Buddhist monastics that were engaged in studying Western science. Thus far, there was no research on the impact of studying Western science on Buddhist monastics’ worldview despite numerous interactions between Buddhist scholars and Western scientists. The Dalai Lama’s engagement with the Western scientific community led to his decision to introduce Western science in Tibetan monasteries in India. By using a sociocultural perspective of learning and the theory of collateral learning, this study examines how six Tibetan Buddhist monks are

situating and/or reconciling their knowledge of biological evolution with their Buddhist worldview. This study finds evidence that Tibetan Buddhist monks do encounter difficulty in accepting certain concepts in evolution like macroevolution and human evolution, and engage in variety of collateral learning.

Who Are We? Mapping Difference among Academics' of Science Teaching and Learning Values and Approaches
Michelle Wooten, University of Alabama
ABSTRACT:
Academics of science teaching and learning express themselves as research contributors among historical narratives regarding the value of science, education, particular research approaches, and the types of bodies that can produce significant contributions. Further, these academics come from a wide variety of training including education, the scientific disciplines, engineering, and psychology, which influence their engagements with other researchers. While Fensham (2004) attempted to qualify science education research as a field, the various modes of contribution enacted by its participants, furthered by their conversation regarding what counts as valuable research, poses possible means of reflection: Who are we? What research practices and pursuits do we value? What do our practices enable and disable for our research community? Accordingly, framed in post-constructivist theorizing posited by Barad (2007) and Roth (2014), I co-constructed narratives with academics who actively contributed toward research in science teaching and learning for at least the decade prior to my interviewing them (2015 – 2016). This paper unfolds my constructing of a diffractive mapping*-in-the-making based on our conversations that I hope will serve as a basis for further conversation among our research community about these questions.

Concurrent Session #2
4:20pm – 5:50pm

Strand 1: Science Learning, Understanding and Conceptual Change
Modeling, Explaining and Reasoning about Matter
4:20pm-5:50pm, Hyatt Bowie ABC
Presider: Mark A. McDermott, University of Iowa

A Study of Elementary Children's Mental Models of Atomic Structure
Carole E. Haeusler, University of Southern Queensland
Jennifer Donovan, University of Southern Queensland
ABSTRACT:
This paper provides empirical evidence that introducing a sub-microscopic understanding of the nature of matter in elementary school supports children's understanding of chemical identity or substance and provides a basis for the synchronous development of children's conceptual understanding of the macroscopic and sub-microscopic nature of matter. The qualitative study used semi-structured individual interviews before, immediately after and 8 weeks after an intervention to ascertain children's understandings. Our data, collected from Grade 3 and Grade 4 classrooms in three schools following a 10 hour intervention using models and interactive activities, shows that many of these children demonstrate understanding that matches that of much older children and is consistent with elements of a published Empirical Learning Progression of Matter (ELPM). The authors propose that leaving the introduction of particle theory until middle school and the more advanced atomic-molecular theory until high school as is common in the Australia and the UK, leaves elementary children without the opportunity to develop a conceptual explanatory framework for everyday phenomena involving matter and may in fact contribute to the development of misconceptions which persist in high school and beyond.

Exploring the Conceptual Affordances of Embodied Explanatory Control of a Gas Pressure Simulation
David E. Brown, University of Illinois, Urbana Champaign
Nitasha Mathayas, University of Illinois, Urbana Champaign
Robb Lindgren, University of Illinois, Urbana Champaign
ABSTRACT:
Dynamic simulations can provide powerful learning experiences for students. We are exploring gestural control of such simulations in an attempt to immerse students more fully in the simulation. It is important to note, however, that there are many possible ways in which elements of a simulation can be controlled with gesture. In a simulation of gas pressure varying with volume, with "embodied phenomena control" (EPC) students could control the macroscopic elements of the simulation by gesturing for a wall to move to decrease the volume for the gas, thus increasing the pressure. Here however, in order to focus student attention on molecular mechanisms, we have focused on gestures that control the interactions of the molecules themselves. With "embodied explanatory control" (EEC) students use gesture to directly control pressure by tapping their palm (representing a movable wall) with their fist (representing the molecules), tapping quickly for high pressure and slowly for low pressure. To our knowledge, EEC has not been explored before, and so it is important to investigate the conceptual affordances of this way of interacting through gesture with a dynamic simulation. Here we look at case studies in which we have explored the conceptual affordances of EEC.

Linking Middle School Students' Chemistry Content Knowledge and Spatial Reasoning
Merryn Cole, University of Kentucky
Jennifer A. Wilhelm, University of Kentucky
ABSTRACT:
This study examines the correlation between middle level students' spatial reasoning ability and their understanding of the particulate nature of matter. The Next Generation Science Standards (NGSS; NGSS Lead States, 2013) bring the particulate nature of matter to the forefront in the 6-8 grade band, where the emphasis is placed on understanding matter and its interactions at the particulate level. Research with college students has shown a correlation between understanding of chemistry content and spatial reasoning ability (e.g., Stieff, 2013). This is the first study to explore the relationship between spatial reasoning and students' understanding of chemistry concepts at the middle school level. We found a significant positive correlation between middle level students' spatial reasoning and their understanding of the particulate nature of matter. Item analysis also showed the mean spatial scores of students choosing the correct answer tended to be higher than for students who chose other answers. These results highlight the need for spatially rich experiences in middle school classrooms to improve the spatial reasoning ability of students. The results also illustrate a need to identify the relationship between different spatial abilities (not just mental rotation) and other chemistry concepts.

Strand 1: Science Learning, Understanding and Conceptual Change
Model-based Teaching and Learning of Science
4:20pm-5:50pm, Hyatt Lone Star E
Presider: May Lee, Michigan State University

Second Graders' Emerging Particulate Models of Matter in the Context of Learning through Model-Based Inquiry
Ala Samarapungavan, Purdue University
Lynn A. Bryan, Purdue University
Jamison M. Wills, Purdue University
ABSTRACT:
This longitudinal study examined second graders' learning about the nature of matter in the context of model-based inquiry instruction that was designed to help them to use particulate models to explain phases of matter and phase changes. Specifically, we examined changes in students' ideas about matter, the coherence of their emerging particulate models, and how classroom science discourse influenced student learning. The guiding questions for this research were: (1) How do second grade students' concepts of matter change as they engage in MPG instruction? (2) To what extent can students apply particulate models they have learned during MPG instruction coherently to explain a variety of macroscopic phenomena such as differences in the behavior of solids, liquids, and gases, or what happens during phase transitions? We found that overall, MPG students showed a significant increase in the use of particulate models of matter to explain a variety of material phenomena such as difference in the behavior and appearance of solids, liquids, and gasses, phase transitions (melting, freezing, evaporation, and condensation), and what happens to particles. Further, MPG instruction resulted in students' more coherent particulate model use to explain states of matter and phase changes.

Impact of Model-based Science Instruction on 3rd-Grade Students' Scientific Explanations for Hydrologic Cycling
Cory T. Forbes, University of Nebraska, Lincoln
Devarati Bhattacharya, University of Nebraska, Lincoln
Ben Baumfalk, University of Nebraska, Lincoln
Tina Vo, University of Nebraska, Lincoln
Laura Zangori, University of Missouri
Christina V. Schwarz, Michigan State University
Greg Welch, University of Nebraska, Lincoln
ABSTRACT:
This quasi-experimental study builds upon previous results from a four year design-based research project involving the development, implementation, empirical study, and revision of a model-centric version of the Full Option Science System (FOSS) Water (2009) unit in 3rd-grade classrooms. Here, we compare students' model-based explanations for hydrologic cycling in classrooms of teachers implementing the modeling-enhanced version of the FOSS Water unit iteratively developed by the project team to those from another set of classrooms using the standard, unmodified version of the same unit. Results demonstrate the effectiveness of modeling-enhanced curriculum due to the implementation of modeling as an instructional practice. By using the scientific modeling as a key component of science instruction, the elementary teachers in using the modeling-enhanced version of the unit were able to moe successfully engage their students in explicit visualization and reasoning about large complex processes. On average, students exposed to the modeling-enhanced version of the curriculum showed greater gains in measured outcomes associated with model-based explanations and they were able to articulate the interaction between water and geosphere by identifying both how movement of water influences geosphere and why water is able to do so.

The Influence of Model-based Science Teaching on Female Students' Attitudes and Confidence Levels

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

ABSTRACT:
In this study we set out to determine whether model-based science teaching influenced the confidence levels and attitudes of high school students compared to their traditionally instructed counterparts, and particularly whether there were any differences by gender. Statistical analysis of students' responses to a science attitude survey as well as their self-reported pre/post instruction problem solving confidence levels indicated that students who learned about electricity through model-based instruction, particularly female students, experienced increased positivity in their attitudes about learning science as well as greater gains in their levels of confidence about scientific reasoning. It is hypothesized that the whole class discussions during which students in the model-based classes were encouraged to cooperatively generate, evaluate and modify their explanatory models, may have particularly appealed to the female learners and contributed to these positive effects.

Using Revised Modeling Ability Analytic Index to Compare Cross-countries Students' Modeling Ability in TIMSS Items
Jing-Wen Lin, National Dong Hwa University
Ruan-Ching Yu, National Dong Hwa University

ABSTRACT:
Due to the lack of assessments on students' science modeling practices, and the difficulty in a cross-countries comparison, this study adopted Authors' (2016) Revised Modeling Ability Analytic Index to analyze TIMSS 2011 G8 items. The aims of this study were to explore the distribution of the TIMSS 2011 G8 items which suitable for assessing modeling ability, in stages of modeling process (i.e. model selection, construction, validation, analysis and application, and deployment) and modeling levels (i.e. Levels 1 to 4, from single factor to extended relation); moreover, compared the modeling performances on related items among Japanese, Korean, Singaporean and Taiwanese students. The findings were: 1. TIMSS 2011 G8 items centered on "model selection" and "model analysis and application" among all stages of modeling process; and over-proportionally measured "the simple relationship among factors" (Level 3). 2. The Singaporean students, who commanded "the simple relationship among factors" in biology, physics, and chemistry, performed the best in cross-countries comparisons. Korean students, who commanded the "simple relationship among factors" only in physics, performed the worst. However, using TIMSS items as modeling practice assessments still requires supplementing the items on model construction, validation and deployment stages in order to examine students' performances in whole modeling process.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set: Promoting Engagement and Learning in Elementary Science Using Multiple Literacies in Project-based Learning
4:20pm-5:50pm, Hyatt Travis AB

ABSTRACT:
In this related paper set, we present the development process and initial implementation results of the Using Multiple Literacies in Project-based Learning (MLs) project. The MLs project is designing, developing and testing eight project-based learning (PBL) units for the upper elementary grades that engage students in sense making using literacy and mathematical practices to develop usable science knowledge. In PBL, students engage in making sense of phenomena to answer meaningful questions through collaboration, investigation and the design of artifacts. Although the materials focus on science teaching and learning, the materials also build literacy and mathematical capabilities in students and create agency and ownership of science learning for diverse learners. The project brings together researchers from three different universities who study science learning, ELA, and diversity in elementary classrooms. This session will have particular value to NARST members as PBL can reshape K-12 science education, particularly since it aligns to the Framework for K-12 science education and is purposefully designed to support all learners. However, more empirically based studies are needed to learn how PBL works across different contexts and how the literacy and mathematics can be integrated with the learning of science.

Using Multimedia Resources and Digital Tools to Engage Third Graders in the Work of Ornithologists
Annemarie S. Palincsar, University of Michigan
Meredith Baker, University of Michgian
Kirsten Edwards, University of Michigan
Miranda Fitzgerald, University of Michigan
Linda Lee Kucan, University of Pittsburgh
Elliot Soloway, University of Michigan

Using Discourse Tools to Foster Student Intentionality in Knowledge Building and Equitable Sense-Making
Emily Miller, University of Wisconsin, Madison

Purposeful Pedagogy: Teachers' Experience with Project Based Learning
Barbara Schneider, Michigan State University

Emily Miller
Joseph S. Krajcik, Michigan State University

Constructing the Practice of Scientific Modeling in Project-Based Elementary Science Classes
Deborah C. Peek-Brown, Michigan State University
Kellie Cunningham, Michigan State University

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
A Symposium on Teaching and Learning about Climate Change: A Framework for Educators
4:20pm-5:50pm, Hyatt Crockett AB
Presenters:
Michael P. Clough, Iowa State University
Elizabeth Hufnagel, University of Maine
Dana L. Zeidler, University of South Florida
Amanda N. Peel, University of Missouri
Charles W. Anderson, Michigan State University
Daniel P. Shepardson, Purdue University
Wendy R. Johnson, Michigan State University
Kirstin C. Busch, Stanford University
J. R. McGinnis, University of Maryland
Glenn Branch, National Center for Science Education
ABSTRACT:
The Intergovernmental Panel on Climate Change (IPCC, 2013) has concluded that global warming is occurring (Bull. Amer. Meteor. Soc. 2016) and that human activity is the main cause. In addition to changes such as rising and increasingly acidic oceans, decreased snow cover, and altered growing seasons, changes in the Earth's climates have human-health and socioeconomic consequences that impact individuals and societies. Thus, it is paramount that educators and students understand the causes and implications of global warming in order to prepare for a changing climate and become informed citizens who participate in democratic decision making regarding a collective future. In this symposium, we will present a framework for educators to enhance climate change education by focusing on three themes: (1) Theoretical, philosophical, and conceptual frameworks for guiding climate change education and research, (2) Research on teaching and learning about global warming and climate change that informs practice, and (3) Approaches to professional development and classroom practice that enhance teaching and learning. As a way to involve our session's audience in the session, a group discussion will follow the panel presentationThe Intergovernmental Panel on Climate Change (IPCC, 2013) has concluded that global warming is occurring (Bull. Amer. Meteor. Soc. 2016) and that human activity is the main cause. In addition to changes such as rising and increasingly acidic oceans, decreased snow cover, and altered growing seasons, changes in the Earth's climates have human-health and socioeconomic consequences that impact individuals and societies. Thus, it is paramount that educators and students understand the causes and implications of global warming in order to prepare for a changing climate and become informed citizens who participate in democratic decision making regarding a collective future. In this symposium, we will present a framework for educators to enhance climate change education by focusing on three themes: (1) Theoretical, philosophical, and conceptual frameworks for guiding climate change education and research, (2) Research on teaching and learning about global warming and climate change that informs practice, and (3) Approaches to professional development and classroom practice that enhance teaching and learning. As a way to involve our session's audience in the session, a group discussion will follow the panel presentation.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Related Paper Set: The Impacts of the Learning Assistant (LA) Models on LA and Student Outcomes
4:20pm-5:50pm, Hyatt Crockett CD
ABSTRACT:
The Learning Assistant Model is an internationally adopted program to support the transformation of undergraduate STEM courses to align with research-based instructional strategies. Goals of the LA model include curriculum and course transformation, institutional change, discipline-based education research, and teacher recruitment and preparation. Research has shown the LA model to be effective in improving students conceptual learning and increasing the number of STEM majors pursuing careers in secondary math and science teaching. This program has been implemented in over 70 institutions. Because each institution brings a variety of contextual affordances and constraints, it is important that researchers have a deep understanding of the impact of the LA experience on students and LAs as well as an understanding of the best-practices for effective student learning within the variety of LA programs. The papers in this session will use a variety of perspectives to investigate the effectiveness of the LA model for both students and LAs. The purpose of this session will be to expand the current understanding of the effects of LA program beyond conceptual learning and teacher recruitment to the areas of LA identity development, LA teaching practices, effects on under-represented minority students, and best-practices for conceptual assessment.

Analysis of Learning Assistants' Physics Identity Development through the Lens of Communities of Practice
Eleanor W. Close, Texas State University
Jessica Conn, Texas State University
Aaron Collins, Texas State University
Rebel Nicholson, Texas State University

Impact of the Learning Assistant Experience on Teachers' Classroom Practice
Kara Gray, University of Colorado, Boulder
Valerie K. Otero, University of Colorado, Boulder

In-class vs. Online Administration of Concept Inventories and Attitudinal Assessments
Manher Jariwala
Ben Van Dusen, California State University, Chico
Eleanor W. Close, Texas State University
Jada-Simone S. White

The Impact of Learning Assistants on Inequities in Physics Student Outcomes
Jayson Nissen, California State University, Chico
Ben Van Dusen, California State University, Chico

Strand 6: Science Learning in Informal Contexts
Symposium: Using Locally Relevant Authentic Inquiries to Engage Youth in Environmental Science Topics Out-of-School
4:20pm-5:50pm, Hyatt Bonham E
Presider: Bernadette Sibuma, Education Development Center, Inc.
Discussant: Caroline Parker, Education Development Center, Inc.
Presenters:
Bernadette Sibuma, Education Development Center, Inc.
Caroline Parker, Education Development Center, Inc.
Lauren B. Birney, Pace University
Ardice Hartry, University of California, Berkeley
Anne Kern, University of Idaho
Kathy Bertram, Alaska Pacific University
Gerald Knezek, University of North Texas
Rhonda Christensen, Institute for the Integration of Technology into Teaching and Learning
ABSTRACT:
This symposium highlights five projects funded by the ---------- (-----) grant program to engage students in authentic science inquiries into issues that are personally or locally relevant to them. The ----- program seeks to increase awareness of and interest in STEM and information and communications technology (ICT) fields among PreK-12 students, with the goal of encouraging students in, and helping to prepare them for, future STEM careers. These projects will share their innovative programs and research results as they relate to using global and local issues to authentically engage youth in environmental science topics in out-of-school settings.

Strand 7: Pre-service Science Teacher Education
Argumentation, Evidence, and Socioscientifiic Issues
4:20pm-5:50pm, Hyatt Lone Star F
Presider: Ibrahim Delen, Usak University

Contribution of the Argumentation-Based Laboratory to Pre-Service Chemistry Teachers' Microscopic Explanations of Chemistry Concepts
Selcuk Kilinc, Middle East Technical University
Mustafa Tuysuz, Yuzuncu Yil University
Esra Sarici, Middle East Technical University
Ceren Soysal, Middle East Technical University
Esen Uzuntiryaki-Kondakci, Middle East Technical University
ABSTRACT:
The purpose of this study was to investigate the impact of argumentation-based chemistry laboratory on pre-service chemistry teachers' (PCT) explanations of chemistry concepts at micro level. A total of 12 PCTs (5 males and 7 females) participated in the

study. Data were collected using Chemistry Concepts Test, essay type questions, and semi-structured interviews. Chemistry Concept Test, which included 24 multiple choice items, was administered as a pre-test to determine pre-existing knowledge of PCTs at the beginning of the semester. The items in the test consisted of high school (grade level 9-12) chemistry concepts such as acid-bases, gases, and reaction rate etc. Results showed that, the mean of the argumentation based laboratory (ABL) group (12.3) was greater than the mean of the traditional laboratory group (TL) (10.0). 60% of the participants in ABL group provided correct explanation at microscopic level (3 points) whereas this percentage for TL group was 40%. In addition, there were three participants possessing incorrect knowledge (0 point) in TL group; however, there was no 0 point in ABL group. Keywords: argumentation, laboratory, micro-level, pre-service chemistry teachers, chemistry eduation

Learning to Teach Science through Socioscientific Issues in Preservice Science Teacher Education
Devrim Guven, Bogazici University
John W. Tillotson, Syracuse University
ABSTRACT:
What do teachers need to know and be able to do in order to teach SSI effectively? What type of experiences may help to develop such knowledge and skills in preservice teacher education? This research includes theoretical argument, design and implementation of modules focusing on learning to teach SSI based science in preservice teacher education. Results from four teacher cases suggest that preservice strategic sequencing of theoretical issues of SSI teaching and learning, SSI learning experience in science methods courses and educative curriculum materials may help preservice teacher to be better prepared to teach science in SSI context. Implications for both pre- and in-service teacher education and research are argued based on findings.

Pre-service Teachers' Thinking About Evidence and Evaluations of Trustworthiness of the Claims in Socio-scientific Issues
Gaye D Ceyhan, Syracuse University
Deniz Saribas, Istanbul Aydin University
Doug Lombardi, Temple University
ABSTRACT:
A regular practice of scientists is to evaluate the connections between evidence and claims about natural and human-induced phenomena. Teacher education may improve understanding of this important nature of science activity, and facilitate teachers to implement argumentative reasoning and evidential thinking approaches into their future science teaching. Furthermore, instructional scaffolds that actively engage individuals in evaluation may be needed to increase understanding of critical evaluation as a scientific practice. This study aimed at probing pre-service science teachers' evaluations about evidence and explanations in a pre-service teacher education course when using an instructional scaffold—called a model-evidence link (MEL) diagram—designed to promote scientific evaluation of alternative explanations. A qualitative content analysis of MEL written tasks and reading assignment reflections were conducted, and found a wide variety of evaluations depending on the nature of the instructional topic (i.e., socio-scientific issues). In most cases, the MEL activity facilitated a greater degree of critical evaluation than participant reflections about author trustworthiness in reading assignments. These findings suggest that critical evaluation is a scientific practice that should be explicitly taught in pre-service science methods courses, which in turn, may increase engagement and understanding about the nature of science in their future classrooms.

Using a Dialogical Argumentation Instructional Model for Integrating Science and Indigenous Knowledge worldviews
Keith R. Langenhoven, University of the Western Cape
ABSTRACT:
This study provide South African science teachers with contextual analytical lenses for responding to the South African National Department of Education policy, to integrate Indigenous Knowledge Systems (IKS) into school sciences. This curriculum design is in response to the glocalisation call by the World Bank and United Nations Educational, Scientific and Cultural Organisation (UNESCO) to authenticate IKS as being beneficial to the knowledge economy in areas such as health, agriculture and education especially in developing countries. A Dialogical Argumentation Instructional Model (DAIM) is used as a conceptual pedagogical framework for implementing an integrated science/IKS teaching and learning environment (Toulmin, 1958; Ogunniyi, 1997,2002). The Contiguity Argumentation Theory (CAT) postulates the view that science and IKS are two complimentary cosmologies and CAT can be used for analysing views, perceptions and opinions of teachers and learners as they encounter science and indigenous knowledge worldviews, especially in multicultural science classes, through DAIM pedagogy. Initial findings point to this teaching strategy as a means for navigating an argumentation-based science discourse. The study further revealed a bias by some schools hosting pre-service school science teachers, towards a teaching and learning regimen focused on examinations rather than promoting a balanced socio-cultural orientation as postulated by educational policy.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers' Understanding of Science
4:20pm-5:50pm, Hyatt Travis CD
Presider: Amy M. Lark, Michigan Technological University

Developing Tools to Support the Growth of Science Teachers' Pedagogical Content Knowledge: Analysis of Narrative
Saiqa Azam, Memorial University of Newfoundland
ABSTRACT:
Pedagogical Content Knowledge (PCK) is a specialized form of teacher knowledge required to teach specific content. Many teacher education programs aim at developing PCK of pre-service science teachers. This paper present formative assessment tools developed to engage pre-service science teachers in activities and discussions to help them develop their topic-specific science PCK. This research is an effort to bridge the two famous terms in teacher knowledge literature: "knowledge of teaching" and "knowledge for teaching." The research on teaching with a view that teachers produce the knowledge along with the experience of teaching, falls into the category, knowledge of/about teaching. The research study transformed the knowledge about teaching science into formative assessment tools to develop knowledge for science teaching.

Pre-service Teachers' Understanding of Modeling-Based Assessment in Science Classrooms
Young Ae Kim, University of Georgia
J. Steve Oliver, University of Georgia
ABSTRACT:
The purpose of this case study is to analyze how pre-service secondary science teachers approach modeling-based assessment in the relation to instructional strategies. This study was conducted with five secondary pre-service teachers enrolled in a required science instructional methods course and practicum. One project that served as a data source called on the pre-service teachers to create an assessment rubric using modeling. The data sources are lesson plans and assessment rubrics using modeling, video-recordings, and semi-structured interviews. Findings indicated that the pre-service teachers planned modeling-based assessment mostly focused on assessing understanding of scientific concepts through modeling than assessing the process of modeling or meta-modeling knowledge. Second, the preservice teachers showed more awareness of the need of multimodal models in science instruction and assessment for diverse learners. Third, they decided that the accuracy of the model, its aesthetical appeal, as well as the model's ability to demonstrate the scientific knowledge and scientific reasoning were important criteria. This paper highlights how the preservice teachers need to be supported in learning about assessment of student learning outcomes using modeling to teach science effectively. We examine how modeling-based assessment enables more authentic assessment in science education.

Supporting Secondary Science Preservice Teachers in Developing Formative Assessment Pedagogical Knowledge and Skills
Benjamin Ho, Alpine Academy High School
Melissa A. Jurkiewicz, Mercer University
ABSTRACT:
Although formative assessment is one of the most important processes that teachers can implement to support student learning, few research studies have examined beginning science teachers and classroom assessment (Luft, Dubois, Nixon, & Campbell, 2014). The aim of this qualitative study is to gain a better understanding of how preservice science teachers enact formative assessment and what they should know and be able to do in regards to formative assessment. We examined the formative assessment pedagogical knowledge and skills of 21 preservice teachers during a secondary science methods course. We utilized a variety of methods to collect data including an open-ended pre and post-assessment, teaching observation notes, lesson and unit plans, and interviews. Three themes emerged from the data: a) although the preservice science teachers developed a better understanding of formative assessment, they still felt overwhelmed with the idea of continuously collecting data from all students and modifying instruction; b) as new science teachers develop knowledge of formative assessment, they have periods of contradictory understandings; and c) the 5E lesson planning model may be useful in helping new science teachers develop an understanding of formative assessment. This study has implications for science teacher preparation programs.

Strand 8: In-service Science Teacher Education
Related Paper Set: Supporting and Developing K-12 Science Teacher Practice, Knowledge, and Leadership Through Vertically Aligned PLCs
4:20pm-5:50pm, Hyatt Republic ABC
ABSTRACT:
With this year's theme, Glocalization of science education in mind, we present a four-paper themed set that examines the implementation of a tri-state K-12 science teacher fellowship designed to improve science teacher knowledge, practice and leadership from within the classroom. Specifically, we examine professional learning communities that are orientated to align with the vertical progressions of knowledge emphasized in NGSS. While PLCs are enthusiastically acknowledged as important for encouraging and supporting professional growth amongst teachers, there is a lack of knowledge in the literature about how PLCs are developed and sustained. Our research team, spread across three states, believe a focus on vertical articulation, as called for in NGSS, may be one approach to supporting teachers' science instruction evolution. The papers use qualitative and quantitative analysis to explore the effectiveness of the fellowship in three different geographical locations in the Northeast, science teacher self-efficacy, the quality of feedback amongst peers in professional learning communities (PLCs), and how such PLCs can benefit and support elementary science teachers.

A Comparative Study of the Implementation of a Multi-site Professional Development Program on Teacher Learning and Instructional Practices in Science
Kelly Riedinger, Oregon State University

Self-Efficacy for K-12 Teachers of Science
Amanda M. Gunning, Mercy College
Peter Hillman, Mercy College
Meghan E. Marrero, Mercy College

Quality of Feedback in Vertically Aligned PLCs
Mika Munakata, Montclair State University
Emily Klein, Montclair State University
Monica Taylor, Montclair State University
Kristen Trabona, Montclair State University
Zareen Rahman, Montclair State University

Effective Development and Support for Practicing Elementary Science Teachers
Peter Hillman, Mercy College

Strand 10: Curriculum, Evaluation, and Assessment
Symposium: Assessing Systems Thinking through Science and Engineering Practices
4:20pm-5:50pm, Hyatt Bonham D
Discussant: Susan Yoon, University of Pennsylvania
Presenters:
Hee-Sun Lee, The Concord Consortium
Daniel N. Damelin, The Concord Consortium
Amy Pallant, The Concord Consortium
Jie Chao, The Concord Consortium
Charles Xie, Concord Consortium
Carolyn Staudt, Concord Consortium
Nanette Dietrich, Millersville University
Susan Yoon, University of Pennsylvania
ABSTRACT:
The purpose of this symposium is to bring together four projects that have developed various approaches to assess student thinking involved in systems and system models, one of the seven crosscutting concepts listed in the Next Generation Science Standards. These projects incorporated systems thinking assessments as part of science and engineering practices such as developing and using models, constructing explanations, using computational thinking, and designing engineering solutions. This array of projects will provide the breadth and depth necessary to generate pedagogical and academic interests in designing and implementing systems thinking assessments in terms of (1) how to conceptualize systems thinking in the context of a science practice, (2) how to design assessment tasks and instruments to collect data from students, (3) how to determine students' performance levels (i.e., scoring), and (4) how to interpret assessment data in relation to other attributes of instruction.

Strand 10: Curriculum, Evaluation, and Assessment
Symposium: New Directions and Longstanding Issues in Assessment of Evolutionary Knowledge
4:20pm-5:50pm, Hyatt Lone Star D
Discussant: Louis Nadelson, Boise State University
Presenters:
Cesar Delgado, North Carolina State University
Kathryn Green, North Carolina State University
Margaret M. Lucero, Santa Clara University
Dianne L. Anderson, Point Loma Nazarene University
Louis S. Nadelson, Boise State University
ABSTRACT:
Research shows that teachers and students may hold alternative conceptions about evolution. In order to better support learning, we must determine and monitor learners' ideas. Assessing knowledge of evolution is an essential part of science teaching and learning. This symposium gathers researchers working on assessment of evolution. Author A developed widely-used Test 1 and now uses it to assess impact of classroom instruction using evolution cartoons. Author C used Test 1 to measure teachers' knowledge of student

conceptions, and explore the relationship between science teaching orientations and knowledge of assessment. Author B is developing an assessment instrument focused on teleological reasoning in evolution. Author D has developed instruments to assess understanding of deep time, which is crucial in understanding evolution. Discussant developed Test 2 for evolution. Symposium participants will describe their most current work, and then reflect on – and invite audience input about – 1) novel uses of assessment instruments for evolution; 2) challenges and issues in instrument development; 3) different item formats; 4) adaptation of tests to younger students. This symposium will discuss, critique and reflect on new and well-established evolution assessment instruments to inform development efforts and to offer suggestions for future research, development, and use.

Strand 11: Cultural, Social, and Gender Issues
Symposium: Structured Poster Session on Culture, Context and Science Assessments: Obstacles or Opportunities for Glocalization?
4:20pm-5:50pm, Hyatt Presidio ABC
Discussant: Steven Semken, Arizona State University
Presenters:
Sharon Nelson-Barber, WestEd
Pauline W. U. Chinn, University of Hawaii, Manoa
Kaui Sang, Hawaii Department of Education
Huihui Kanahele Mossman, University of Hawaii
Irasema Ortega, University of Alaska-Anchorage
Steven C. Semken, Arizona State University
ABSTRACT:
Speakers will present results of their investigations on assessment and culture and will address philosophical, theoretical, and measurement issues they have had to consider as they use assessments in diverse U.S. student populations. This structured poster session will offer discussion and empirical evidence about approaches to test construction and administration that have been created and evaluated for different cultural groups. The intent of this session is to lead toward a conceptual framework for improving the ability of test items to appropriately indicate the level of student assessment within specific cultures, to review existing research studies of specific populations, and to present new questions for future research on culture and student assessment.

Strand 14: Environmental Education
Climate Change, Religious Worldviews
4:20pm-5:50pm, Hyatt Bonham C
Presider: Barry Golden, University of Tennessee

Development of a Contextualized Spatial Thinking Assessment for Enhanced Greenhouse Effect
Heather J. Skaza Acosta, Florida Gulf Coast University
Marykay Orgill, University of Nevada, Las Vegas
Kent J. Crippen, University of Florida
ABSTRACT:
Environmental issues are characteristics changing in time and space, often in ways we wish they were not. Improving learners' spatial thinking abilities can improve how they understand complex environmental issues.This project began the work of developing contextualized spatial thinking assessments for environmental issues by developing a method to collect data for assessment development and designing the first iteration of a spatial thinking assessment for an example problem, enhanced greenhouse effect. Existing literature provided a strong content and spatial thinking foundation for assessment design, while expert perceptions were critical to connecting spatial thinking ideas to the content of enhanced greenhouse effect. This work is critical to understanding how our environmental education interventions impact learners' understanding of complex environmental issues for more sustainable decision-making.

Is Climate Change being Taught in U.S. Schools? An Analysis of Science Frameworks
Barry Golden, University of Tennessee
Amelia Brown, University of Tennessee
ABSTRACT:
In recent years, the science of climate change has become increasingly accepted by leading scientific institutions such as the National Academy of Sciences, the American Association for the Advancement of Science, and more. In fact, recent scholarship shows that over 97% of climate science studies support the consensus, indicating not only that temperatures are increasing, but that human activity via fossil fuels is the primary causal agent. Given these recent advances, it makes sense to examine the content of science standards in the United States to see the extent to which the overwhelming science is reflected in curricular standards. We analyzed each state's science framework on a 0-4 scale. A four indicates that the frameworks include a standard that not only addresses climate change, but that includes climate change in a stand-alone standard, and that addresses anthropogenic causality. We found that only

twenty states scored a four, mostly by virtue of having adopted the NGSS standards, while twenty states scored a zero or one. We discuss the nuances of these frameworks in terms of what they indicate for learning about climate change in formal education settings. Despite its content existing in many states, some important problems loom, including those of finding appropriate content areas from which to teach students, and also the massive professional development effort needed to prepare teachers.

Moving beyond a Knowledge Deficit Perspective & Towards a Theory of Climate Change Action for Youth
K.C. Busch, Stanford University
ABSTRACT:
Even though climate change will have a profound impact on today's youth, many American teenagers do not perceive it as a risk and many youth do not take mitigating action. Why might this be and how can climate change education be a lever for change? To explore possible mechanisms involved in the choice of taking mitigating action, several factors highlighted within behavior theory literature were measured to create a theoretical model for youth's choice to take mitigating action. The factors explored were: knowledge, certainty, affect, efficacy, and social norms. The experiment was conducted with 453 middle and high school students within the Bay Area. It was found that efficacy and social norms were direct determinants of pro-environmental behaviors. The cognitive variables – knowledge and certainty – and the psychological variable – affect – were not significant predictors of pro-environmental behavior. The implications for this study are that while students hold basic understanding of the causes and effects of climate change, this understanding lacks personal relevance. Another implication of this study is that if we wish to have action-taking as an outcome of climate change education efforts, then the learning activities should include components to address efficacy and social norms.

Relationships among Evangelical College Students' Worldviews and their Anthropogenic Climate Change Literacy
Joel Light, University of Northwestern, St. Paul
Fred Finley, University of Northwestern, St. Paul
ABSTRACT:
Research is warranted on how a student's worldview relates to his/her anthropogenic climate change knowledge, belief, and acceptance of anthropogenic climate change (ACC). ACC is the one of the most challenging issues today. In the U.S., evangelicals are the most resistant accepting ACC. Why some evangelicals accept ACC and why many do not is not well understood. The study focused the environmental, religious, economic, political, and epistemological areas of participant's worldview. Differences emerged between study participants through qualitative analysis of participant responses to the study's instruments. The data suggests the strong possibility that religious beliefs are at the core of evangelical worldviews. The data showed that specific religious beliefs largely influence whether a person accepts or resists ACC. Certain religious beliefs such as social justice and creation care seemed to be the best potential avenues for solidifying acceptance of ACC and encouraging climate action. The data showed that when religious beliefs are shown to be connected and consistent with ACC impacts and action, evangelicals are more likely to engage in the ACC conversation and movement. Beliefs such as these may be the starting point for the ACC conversation with a member of the evangelical culture.

Social-cultural Anchors for Sustainability within Israeli Youth Movements: Comparison among Secular, Religious and Ultra-orthodox Movements
Daphne Goldman, Beit Berl College
Sara Pe'er, Oranim
Bela Yavetz, Kibbutzim
ABSTRACT:
In efforts to promote sustainability in society, formal education and non-formal education are recognized as complementary frameworks for environmental education. In Israel, youth movements (YMs) comprise a main agent for non-formal education of youth, and provide a pre-existing youth-engagement-framework in which civic engagement can be expanded to address environmental challenges. Israeli YMs are not a homogenous group. One major source of social-cultural diversity is the YM's religious identity. Based on this, the YMs can be categorized into secular, religious and ultra-orthodox. This study compared, among these three groups, the environmental literacy(EL) characteristics of YM members who are 'young-guides' for the younger age-groups, and the YM leaders' perspectives of sustainability. The participant groups were selected due to their potential for influence within the YMs. Significant differences were found in members' EL among the three groups. Members of secular YMs demonstrated greater EL and openness to including pro-environmental activities within their YM branch. 'Judaism as a point-of-departure and platform for sustainability' is one of the themes concerning sustainability in relation to the philosophy and activities of the YMs which emerged from the leaders' interviews. For the religious and ultra-orthodox YMs, this may provide an anchor for meaningful EE and incorporation of sustainability.

Strand 15: Policy
Related Paper Set: Detailed Examination of Intervention Research in Science Education: Findings from Three Large-scale Meta-analyses
4:20pm-5:50pm, Hyatt Bonham B

Discussant: Erin Furtak, University of Colorado

ABSTRACT:
Several recent policy documents have called for researchers to conduct more intervention studies in science education. In 2011, the National Research Council concluded that "federal agencies should support research that disentangles the effects of school practice from student selection (p. 28)." Likewise, A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (2012) asked, "What instructional interventions (e.g., curriculum materials, teaching practices, simulations or other technology tools, instructional activities) can move students along a path from their initial understanding to the desired outcome (p. 313)?" But the call for intervention research by influential groups such as the National Research Council and Achieve raises important questions. What is the current state of experimental and quasi-experimental intervention studies in science education? What are the publication patterns? Are intervention studies equally distributed across teacher and student outcomes? What are the funding patterns for intervention studies? Answers to these questions have important policy implications in that they may drive funding and research priorities. We address these questions in our related paper set.

Logistics and Techniques for Conducting Large-scale Meta-analyses Subject/Problem
Qi Z Zhang, Western Michigan University
Qian Wang, Western Michigan University
Karen Askinas, BSCS
Joseph A. Taylor, BSCS
Susan M. Kowalski, BSCS

A Large-scale Statistical Meta-Analysis of Student Science Outcomes
Joseph A. Taylor, BSCS
Susan M. Kowalski, BSCS
Karen Askinas, BSCS
Qi Zhang, Western Michigan University
Qian Wang, Western Michigan University

A Large-Scale Meta-Analysis of Teacher Interventions in Science Education
Karen Askinas, BSCS
Susan M. Kowalski, BSCS
Joseph A. Taylor, BSCS

A Descriptive Meta-analysis of the Federally Funded Portfolio of Science Education: NSF, NIH, and IES
Susan M. Kowalski, BSCS
Joseph A. Taylor, BSCS
Karen Askinas, BSCS
Erin M. Furtak, University of Colorado

Concurrent Session #3
8:30am – 10:00am

International Committee Sponsored Session
Admin Symposium: 13 Questions: Reframing Education's Conversation: Science
8:30am-10:00am, Hyatt Republic ABC
Discussant: Lynn A. Bryan, Purdue University
Presenters:
Lucy Avraamidou, University of Groningen, Netherlands
Ana Becerra, Comunidades Justas/Just Communities
Carolina Castano Rodriguez, Australian Catholic University
Rowhea Elmsky, Washington University
Anita Hussenius, Uppsala University, Sweden
Shakhnoza Kayumova, University of Massachusetts, Dartmouth
Femi Otulaja, University of the Witwatersrand
Michael Reiss, University College of London
Christina Siry, University of Luxembourg
Lily Taylor, Murdoch University, Australia
ABSTRACT:
This session is based on the forthcoming book, 13 Questions: Reframing Education's Conversation: Science (Bryan & Tobin (Eds.), 2017). 13 Questions: Science raises critical questions in science education that scholars and practitioners might consider as they enact science education in a dynamic and evolving universe threatened by issues of sustainability and disharmony For example: Power and Science Education: Who decides the forms science education has taken and who should decide?; The Science Curriculum: What are the basics and are we teaching them?; (In)Equity and Science Education: In what ways does (in)equity affect the process of science education?; Science Education as a Political Issue: What's missing in the public conversation about science education?; Science Education Visions: What is school science for and what should we be doing in the name of science education?. The authors, who embraced an array of sociocultural theories, respond to these questions with standpoints that provoke, expand, and enlighten readers about possibilities for being, acting, transforming, and enhancing the social and physical worlds we inhabit and for which we are stewards. Participants of this session are invited to engage in dynamic and critical dialogues about science education with the authors from 13 Questions: Reframing Education's Conversation: Science.

Strand 1: Science Learning, Understanding and Conceptual Change
Related Paper Set: Bringing Together Research Traditions: What Can Learning Progressions and Teaching-Learning-Sequences Designers Learn from Each Other?
8:30am-10:00am, HBG Convention Center 006D
Presiders:
Alicia C. Alonzo, Michigan State University
Italo Testa, University Federico II, Napoli, Italy
Discussant:
Charles W. Anderson, Michigan State University
ABSTRACT:
This related paper set brings together researchers working in two related, but largely parallel, research traditions. Researchers in the US have focused on learning progressions (LPs)—"descriptions of the successively more sophisticated ways of thinking about a topic that can follow one another as students learn about and investigate a topic". In European countries, researchers have engaged in iterative development of teaching-learning sequences (TLSs). A TLS is an "interventional research activity… comprising well-validated teaching-learning activities empirically adapted to student reasoning." To date, differences in the educational contexts of LPs and TLSs have seemingly overshadowed common ground, leading to a separation that has prevented researchers from sharing and benefiting from each other's' work. The aim of this related paper set is to explore how LP and TLS researchers may benefit from sharing methods and findings, while not overlooking differences (e.g., time scale, content breadth, relationship to curriculum). Each of the five papers takes a different perspective on recent issues and trends with regard to LPs or TLSs, providing meaningful insights into students' learning pathways. Together, the five papers show that, despite unavoidable differences, the former separation of these research traditions should be reconsidered in light of methodological and empirical similarities.

Developing Learning Progressions for Momentum and Mechanical Energy: Insights for Instruction
Alicia C. Alonzo, Michigan State University
Alexander Robinson, Thornapple Kellogg High School, Middleville, MI

Designing a Three-Dimensional Curriculum for Climate Change Education Informed by Learning Progression Research
Hannah K. Miller, Johnson State College
Wendy R. Johnson, Michigan State University
Charles W. Anderson, Michigan State University

Iterative Refinement of Teaching Learning Sequences: The Cases of Optical Properties of Materials and Floating/Sinking
Italo Testa, University Federico II, Italy
Petros Kariotoglou, University of Western Macedonia, Greece
Dimitris Psillos, University of Thessaloniki, Greece

Improving Student Understanding of Quantum Mechanics Concepts Using a Quantum Interactive Learning Tutorial
Emily M Marshman, University of Pittsburgh
Chandralekha Singh, University of Pittsburgh

Evaluating and Redesigning Introductory Physics Teaching Learning Sequences
Kristina Zuza Elosegi, University of Basque Country, Spain
Jaume Ametller, Universitat de Girona, Spain
Jenaro Guisasola , University of Basque Country, Spain

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set: Deepening Students' Understanding of Modern Genetics: Four Approaches that Link Molecular Genetics with Mendelian Genetics
8:30am-10:00am, HBG Convention Center 007A
Presider: Anat Yarden, Weizmann Institute of Science
Discussant: Grady Venville, University of Western Australia
ABSTRACT:
Although learning about molecular mechanisms that link genotype to phenotype is part of the upper secondary biology curriculum in most countries, many studies report that students fail to connect molecular knowledge to phenomena at the higher level of cells, organs, and organisms. In this related paper set, we integrate research carried out on Grade 10 through college introductory biology students in the US, Israel, and Spain, to pursue a shared understanding of current means used to deepen students' understanding of modern genetics. The four selected studies are grounded in the theoretical framework suggested by Stewart, Cartier, and Passmore (2005) which claims that knowledge of three integrated conceptual models is necessary to truly understand genetic phenomena: the genetic model, the meiotic model, and the biomolecular model. Prior research shows that students have difficulties connecting the three models even with instruction. Four different approaches to address these difficulties, the various means taken to enhance students' ability to connect between the three models and encouraging outcomes that show deepening students' understanding of modern genetics, will be presented in this session.

Students' Molecular Genetics Explanations of Inheritance Patterns
Moriama Castro-Faix, Rutgers University
Ravit Golan Duncan, Rutgers University

High School Students' Ability to Connect Three Conceptual Models in Genetics
Michal Haskel-Ittah, Weizmann Institute of Science
Anat Yarden, Weizmann Institute of Science

Difficulties in Integrating the Genetic-Meiotic and Genetic-Molecular Models of Genetics
Amber Todd, Wright State University
William L. Romine, Wright State University

Interactions between Modeling and Argumentation while Building the Model of Gene Expression
Noa Ageitos, Universidade de Santiago de Compostela
Blanca Puig Mauriz, University of Santiago de Compostela
Grady J. Venville, University of Western Australia

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Related Paper Set: Learning Disciplinary Knowledge through Engineering Design in the Elementary Grades
8:30am-10:00am, Hyatt Crockett AB
ABSTRACT:

The integration of engineering and science education provides new challenges and opportunities for elementary teachers and students. Engineering curricula often pose design challenges for students that necessitate the use of knowledge across disciplines (science, math, and literacy), situate problems in social contexts, and require creative solutions. Each of the four studies in this related paper set offers a different perspective on the ways that engineering education can support the development of student learning of disciplinary knowledge and practices through design challenges. The topics studied include a randomized controlled efficacy study of science and engineering learning, discourse analysis of science learning opportunities created from engineering design, multimodal analysis on uncertainty in small group work in engineering, and learning to improve from initial failure in design. The paper set gathers results across methodological approaches to examine the opportunities engineering provides in elementary classrooms. The results of the studies identify how to structure curricula and student work to support the development of disciplinary ideas and practices.

An Efficacy Study of [Engineering Curriculum (EC)]: Quantitative Modeling of Outcomes
Cathy P. Lachapelle, Museum of Science
Christine M. Cunningham, Museum of Science, Boston
Yoonkyung Oh, Pennsylvania State University

Learning Science through Engineering Design
Gregory J. Kelly, Pennsylvania State University
Christine M. Cunningham, Museum of Science, Boston
Carmen M. Vanderhoof, Pennslyvania State University
Peter R. Licona, Pennsylvania State University

Managing Uncertainty within Elementary Engineering Groups
Carmen M. Vanderhoof, Pennslyvania State University

"Success" is Not the Only Goal: Improvement from Failure in Elementary Engineering Projects
Matthew Johnson, Pennsylvania State University
William S. Carlsen, Pennsylvania State University

Strand 5: College Science Teaching and Learning (Grades 13-20)
Related Paper Set: Modeling in Undergraduate Biology: Unpacking Students' Representations of Systems
8:30am-10:00am, HBG Convention Center 007C
Presiders:
Jennifer L. Momsen, North Dakota State University
Tammy Long, Michigan State University
ABSTRACT:
Models are fundamental tools used by scientists to represent and evaluate knowledge, foster collaboration and communication, and test hypotheses about system properties. Despite the ubiquity of models and modeling in science practice, college biology learners, particularly in introductory courses, rarely engage in modeling activities beyond interpretation of provided models in textbooks. Creating and interpreting models of all types is increasingly emphasized as a core competency in biology curricula at all levels. At the undergraduate level, little research has investigated how the practices of creating and interpreting models impact student learning of biology or support the development of discipline competency. In this related paper set, we present research that explores undergraduate students' views about models, and development of modeling abilities. We specifically examined how introductory biology students perceive models, how cognitive and contextual factors influence students' model construction, how student-generated models of biological systems and processes align with their written explanations, and how students use models to generate predictions about system dynamics.

How do Undergraduate Students Perceive Models in a Model-based Introductory Biology Course?
Caleb Trujillo, Michigan State University
Steve Bennett, Michigan State University
Tammy Long, Michigan State University

Student Use of Deep Approaches to Modeling in an Introductory Biology Course
Steve Bennett, Michigan State University
Amelia Wenk Gotwals, Michigan State University
Tammy Long, Michigan State University

Analyzing Student Models from a Functional Perspective
Amanda Sebesta, St. Louis University
Hannah Aherrera, St. Louis University
Elena Bray Speth, Saint Louis University

How Well Do Student Models Align with their Written Explanations?
Elena Bray Speth, Saint Louis University
Adam Reinagel, St Louis University
Sara Wyse, Bethel University
Kari Blom, Bethel University

How Do Students Use Models of Biological Systems to Make Predictions?
Jennifer L. Momsen, North Dakota State University
Sara Wyse, Bethel University

Strand 5: College Science Teaching and Learning (Grades 13-20)
Biology and Environmental Learning
8:30am-10:00am, Hyatt Crockett CD
Presider: Emily M. Walter, California State University

Increasing Undergraduate Cell Biology Performance through Writing-to-Learn
Meena M. Balgopal, Colorado State University
Anne Marie Casper, Colorado State University
Alison M. Wallace, Minnesota State University Moorhead
Paul J. Laybourn, Colorado State University
Ellen Brisch, Minnesota State University, Moorhead
ABSTRACT:
Writing-to-learn (WTL) tasks in lecture courses can help biology students increase content knowledge, improve performance, and ultimately communicate their understanding of content. WTL activities can model how scientists use inductive reasoning to design studies and arguments; encourage revision of ideas; support peer review and discussion; and help with writing-to-communicate (WTC) tasks. Our WTL interventions included the use of graphic organizers, iterative writing, peer evaluation, and self-evaluation. We examined the effects of WTL on content knowledge, performance (grades), and retention of undergraduate students studying cell biology at a large western US university. We found that 1) all students improved on their posttests, 2) WTL students outperformed their peers in WTC sections, but the difference was particularly noteworthy for minority students, 3) WTL students outperformed their peers in WTC sections, and those with more WTC tasks outperformed peers with less WTC, 4) almost all students in our intervention conditions remained in STEM disciplines during and after the study, and 5) the use of more abstract cell biology terms increased significantly over the semester for all students in the WTL condition, but this increase was particularly noteworthy for minority and first generation students compared to their peers in WTC comparison conditions.

Simulated Computational Model Activity Improves Conceptual Understanding about Biological System
Heather E Bergan-Roller, University of Nebraska, Lincoln
Nicholas J Galt, Valley City State University
Tomá Helikar, University of Nebraska, Lincoln
Joseph Dauer, University of Nebraska, Lincoln
ABSTRACT:
College life sciences curricula have been evolving to better emphasize skills required in the 21st century, including systems thinking, quantitative reasoning, critical thinking, etc. To help students develop these skills, we have developed a learning approach centered on computational models and simulations so that students can learn about the dynamic nature and immense complexity of biological systems. Our learning approach combines an interactive software (learn.cellcollective.org), where students build and simulate computational models, and learning modules in which students investigate the biological system through simulations. To test how our learning approach impacted student conceptual understanding, we used pre/post conceptual model assessments and exam performance in the context of a cellular respiration module. This module was implemented in a large introductory life sciences laboratory. We found that students increased the quantity and quality of conceptual models of cellular respiration after the simulation module. Furthermore, students who engaged in the simulation module performed better on exam questions that students who did not engage in the module. Our study indicates that our computational modeling approach can be used to improve how students connect concepts and retrieve knowledge within biological systems.

The Impact of an Environment-driven Socioscientific Issue Intervention on Undergraduate Students' Environmental Consciousness
Hsin-Hui Wang, National SunYat-sen University
Zuway-R Hong, National Sun Yat-Sen University
Huann-Shyang Lin, National Sun Yat-Sen University
Hsiang-Ting Chen, National SunYat-sen University
Kuay-Keng Yang, National SunYat-sen University
ABSTRACT:

The purpose of this study was to determine the effects of an Environment-driven Socioscientific Issues (EDSSIs) intervention on college students' environmental conscientiousness. A one group pretest-posttest design was employed. Thirty-nine college students from a comprehensive university participated in a semester-long study; they come from different majors enrolling a general-liberal required elective course. These students attended a 17-week intervention, which focused on demonstrating and observing environmental issues, self-reflection, group discussions and SSIs teaching approach. All students completed a 50-item Environmental Questionnaire (EQ) that was derived from Programme for International Student Assessment (PISA) Attitudes towards Environment to assess students' environmental conscientiousness. Confirmatory factor analyses (CFA), t-tests, and Analyses of variance (ANOVAs) were conducted to analyze participants' responses to the pre- and post-test across all dependent variables. Essential findings revealed that college students' environmental consciousness can be cultivated through EDSSIs intervention , especially on awareness of environmental issues, responsibility for sustainable development, environmental self-efficacy, and environment-related activities. Surprisingly, we found that the undergraduate non-science majors' environment-related activities didn't show any significant improvement while the low achieving students' environmental consciousness didn't make any significant enhancement through the intervention. Educational implications and recommendations are discussed. Key words: college students; environmental consciousness; environment-driven; socioscientific issues intervention

The Science Research Resource Generator: Undergraduate Sophomore Biology Students' Perceptions of their Social Capital
Katherine Doerr Morosky, The University of Texas, Austin
Erin L. Dolan, University of Georgia
ABSTRACT:
Learning through a research apprenticeship has acknowledged benefits for undergraduate science education. While other approaches, such as course-based research experiences, hold advantages, research apprenticeships remain a desirable and widely used component of undergraduate science education. However, given their resource-intensive nature, apprenticeships are scarce and competitive positions. This paper reports on a resource generator method of understanding undergraduates' social capital in securing science research opportunities. Approximately 350 sophomore biology students provided survey responses that were analyzed based on sociodemographic factors. We found that attending a smaller university has a positive correlation with high social capital, while family education background has no significant correlation. These findings show that, when considering how to make undergraduate research experiences more widely available to science students, the practices of smaller universities may be emulated. Moreover, the advantages of family educational background appear to be obviated by the second year of college, for this sample of biology students.

Strand 6: Science Learning in Informal Contexts
Science Learning in and about Nature - B
8:30am-10:00am, HBG Convention Center 007B
Presider: Jennifer Dewitt, UCL Institue of Education

Defining and Developing Curricula in Informal Science Education Contexts
Martin H. Smith, University of California, Davis
Steven Worker, University of California
Lynn Schmitt-McQuitty, University of California
Cheryl L. Meehan, University of California
Andrea P. Ambrose, University of California
Kelly M. Brian, University of California
Emily A. Schoenfelder, University of California
ABSTRACT:
Effective curricula are a cornerstone of successful programming in informal science education. However, there is no universal operationalized definition of curriculum. Additionally, the development of curricula requires a systematic process that takes into account numerous factors. This paper provides a definition of curriculum by describing the component parts, discussing the organization of those elements, and recommending theoretical frameworks that complement effective teaching and learning in science. The paper also describes strategies to help guide curriculum development, adaptation, and evaluation.

Elementary School Students' Experience in Science Museum – What Do They Like or Dislike?
Neta Shaby, Ben-Gurion University of the Negev, Israel
Orit Ben Zvi Assaraf, Ben-Gurion University of the Negev, Israel
Tali Tal, Technion
ABSTRACT:
This research focuses on how schoolchildren visiting a Science Museum with their class perceive the overall experience of their visit to the science museum. Our population consisted of 72 4th grade students (age 10) who came to the museum with their class for a day visit. Students were from four classes from four different schools. The goal of the study was to highlight the elements of a museum visit that students in the 4th grade like or dislike. It employed a qualitative research methodology, interviewing students, sorting their responses into categories and creating a category tree of the students' museum experience. This information can add to existing visitor data and help make the museum experience more effective for school students. A visit to the museum involves multiple sources of experience and information, which collectively contribute to the individual's experience. Our research revealed several experiences that impact school children most prominently during the visit. For example, physical experience in the museum is a very dominant part of the visit. Social interaction was mentioned by the students less prominently than expected, but was nevertheless particularly noteworthy due to the nature of the social interaction that was marked by students as important.

Participation in Informal Science Learning Experiences: The Rich Get Richer?
Jennifer DeWitt, UCL Institute of Education
Louise Archer, UCL Institute of Education
ABSTRACT:
Informal science learning experiences have been found to provide valuable opportunities to engage with and learn about science and, as such, form a key part of the STEM learning ecosystem. However, concerns remain around issues of equity and access. The [project name] study builds upon previous research in this area and uses the construct of 'science capital' to understand and support science engagement among young people, particularly those historically marginalized from science. Drawing on survey data from nearly 6000 children ages 11-16 in England, we investigate who participates in particular areas of informal STEM learning outside of the science classroom. Survey findings are illustrated by interview data from 72 students from the same sample. Analyses suggest that overall participation in different types of informal science learning experiences ('informal' learning experiences, 'everyday' learning experiences, and school-led enrichment) varies. Generally, students from more privileged social backgrounds participate more, but with further ethnic and gender patterns between different ISL activity types. These differential patterns of participation highlight how some areas of the ecosystem (e.g., 'everyday' learning experiences) are more accessible, while others (e.g., in designed spaces and school-led enrichment) could do more to address inequities in participation.

Perceived Levels of Self-Efficacy in Informal Science Educators
Megan Ennes, North Carolina State University
Gail Jones , North Carolina State University
Katherine Chesnutt, North Carolina State University
Hardin Engelhardt, Marbles Children's Musuem
ABSTRACT:
Learning in out of school settings such as informal science centers plays an important role in increasing public understanding of science. The number of informal science educators is growing every year, however, little is known about their preparation and professional development. An exploratory study surveyed 299 informal science educators to examine their levels of perceived self-efficacy in skills related to pedagogy and science content. High levels of self-efficacy have been shown to influence educators' decision making and teaching skills. Identifying the areas where informal science educators feel the need for more professional development allow professional development opportunities to target these areas to help improve self-efficacy. The results of this study showed that participants' greatest need for professional development was in the areas of facilitation and a need for increased science knowledge. Over 40% of respondents indicated they needed help encouraging visitors think about ways to engage science policy and decision-making, successfully engaging visitors who seek to disrupt the visitor/staff interaction, and increasing their ability to recognize the way people of different ethnicities/races or cultural backgrounds interact and communicate. Sixty percent of respondents expressed a need for increased skillfulness in helping visitors understand physics and chemistry concepts.

Visitors and Alignment: Actor-network Theory and the Ontology of Informal Science Institutions
Patricia Patrick, Consultant
ABSTRACT:
As informal science institutions play a larger role in science education, there is an increased need to research and understand how society identifies the brand of each institution. In this study, I apply actor-network theory (ANT) as a way to view the actors within and outside an ISI and define visitors' understandings about the institution. The practice of applying ANT explores the webs of the social and natural worlds and describes the relationships that occur. For the purpose of this paper, a zoo served as the example institution. Even though the example in this study is a zoo, the conclusions and discussion focus on how ANT may be used in a similar way across museums to define visitor knowledge of the institution. ANT may be applied by any institution to define its self-identity and tell the story of how the institution is viewed by visitors.

Strand 7: Pre-service Science Teacher Education
Symposium: Affordances and Challenges of Framing Science Teacher Preparation Programs around Core Practices
8:30am-10:00am, HBG Convention Center 006B
Presenters:
Ron Gray, Northern Arizona University
Melissa Braaten, University of Colorado, Boulder
Danielle K. Ross, Northern Arizona University
David Stroupe, Michigan State University
Elaine V. Howes, American Museum of Natural History
Daniel Wolff, American Museum of Natural History
John Settlage, University of Conneticut
Scott McDonald, Pennsylvania State University
Heather J. Johnson, Vanderbilt University
Kirsten K. Mawyer, University of Hawaii
ABSTRACT:
In this interactive poster session symposium, we will examine the affordances and challenges of framing science teacher preparation programs around core practices (e.g., ambitious science teaching). Many science teacher educators have begun this work due to the recent turn toward practice-based teacher education (Grossman, Hammerness, & McDonald, 2009) as well as the challenges associated with implementing the Next Generation Science Standards. However, much of this work has been conducted in individual courses (e.g., science methods). In this session, we seek to further the ongoing rich conversation by examining the ways in which core practices can be utilized across programmatic elements such as among courses and between courses and practicum experiences. We will present eight posters that offer examples of the integration of core practices within programs and/or empirically examine the associated affordances and challenges therein. Participants and attendees will collectively and collaboratively discuss the implications of practice-based teacher education at a program level as well as possible directions for future research in this area.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers' Learning of Inquiry-based Teaching
8:30am-10:00am, HBG Convention Center 007D
Presider: Cheryl T. Horton, UNC-Chapel Hill

Assessing the Development of Pre-service Biology Teachers' Inquiry Competence: An Approach to Evaluate Learning Opportunities
Sabrina Mathesius, Freie Universität Berlin
Till Bruckermann, University of Cologne
Maria-Elisa Puhlmann, Freie Universität Berlin
Kirsten Schlüter, University of Cologne
Annette Upmeier Zu Belzen, Humboldt-Universität Zu Berlin
Dirk Krueger, Freie Universitaet Berlin
ABSTRACT:
The aim of this study was to assess the scientific inquiry competence of pre-service biology teachers during their academic education. We used a measurement instrument with 123 multiple-choice-items for the two inquiry methods “conducting scientific investigations” and “using scientific models” and asked 4.375 pre-service science teachers in six universities. This presentation focuses on a sub-sample of 1.016 pre-service biology teachers from two universities. Item parameters were estimated using a one-dimensional IRT model and multiple latent regressions were used to analyze students’ competences. In addition, an intervention with theory-based learning opportunities for pre-service teachers was conducted in a pre-post-design. In this training, inquiry strategies are made explicit through scaffolding the learning process. Such scaffolds include communicating the process, reflecting on it by asking students to explain their thoughts and strategies as well as giving feedback. Concerning the competence assessment positive effects can be found for the predictors study stages. As we predicted students in more advanced stages of academic education performed better in the test. It is discussed to what extent implicit and explicit approaches influence the development of competences. In the intervention it was shown as a significantly effective concept in the graduated and in the under-graduated study program.

Challenges Pre-service Science Teachers Face when Implementing a 5E Inquiry Model of Instruction
Ramya Enugu, Texas Christian University
Hayat Hokayem, Texas Christian University
ABSTRACT:
This study examines the challenges that pre-service teachers (PST) face when teaching using the 5E inquiry model and their perspective on how to overcome those challenges. The data sample was 55 PSTs and the data sources consisted of inquiry-based lesson plans, PST interviews, peer teaching observational notes, and field notes to investigate those challenges. The data were coded through designed rubrics for lesson plans and peer teaching sessions and were analyzed using constant comparative method. The

results of this study showed that PSTs faced several challenges regarding the content and method. The content related challenges were difficulty with explain and elaborate phases of the 5E. The method related challenges were managing the time to teach the 5E model, and mapping the lesson to the different parts of the 5E model. The results also showed several solutions such as having solid science content through engaging in different experiences, and having more practice with the 5E lesson planning. This study has implications for the teacher education programs to prepare teacher candidates with strong content knowledge, and to design successful interactions of PSTs with in-service cooperating teachers as mentors.

Exploring the Impact of a Museum-based Teacher Preparation Program on Emergent Science Teaching Practices
Bernadette Doykos, University of Southern Maine
Catherine Fallona, University of Southern Maine
David L. Silvernail, University of Southern Maine
ABSTRACT:
The proposed paper offers an in-depth exploration of the teaching practices of several graduates from a museum-based Masters in Teaching (MAT) program developed to prepare science teachers to succeed in high-needs schools. The MAT program prioritizes the inclusion of diverse strategies to engage youth in science through inquiry-based approaches to teaching and learning as taught by teams of teacher educators and scientists, using a variety of formal and informal learning opportunities. Collectively, the research findings identify strengths and ongoing challenges that early career teachers face in teaching science. The research presented in this symposium seeks to add to the existing literature of teacher preparation and ongoing support in the early years of teaching surrounding science instruction in high needs schools.

Prospective Noyce Teacher Candidates' Pedagogical Orientations towards Inquiry Science Teaching
Rebekka Darner Gougis, Illinois State University
Frackson Mumba, University of Virginia
Kara E. Baldwin, Illinois State University
William J. F. Hunter, Illinois State University
Anthony W. Lorsbach, Illinois State University
ABSTRACT:
This study reports on the prospective Noyce pre-service science teachers' pedagogical orientations towards science teaching before and after receiving instruction on inquiry instruction. Data was collected using Pedagogy of Science Teaching Test 1 (POSTT-1) instrument developed by Schuster et al (2012). Results show that most prospective Noyce pre-service science teachers' initial pedagogical orientations toward science teaching centered on students exploring a phenomenon or idea, with the teacher guiding them towards the desired science concept or principle arising from the activity. After instruction most participants' pedagogical orientations centered on allowing students to explore a phenomenon or idea as they wish and devise ways of doing so, and students would present what they did and discovered. In general, most participants' pedagogical orientations towards science teaching changed from guided inquiry to open inquiry science teaching after the intervention. These findings suggest that it is possible to identify prospective pre-service science teachers' initial pedagogical orientations towards science teaching, and use the results to develop the intervention that is aimed at developing high level inquiry pedagogical orientations among pre-service science teachers. Results have implications on science teacher preparation, and science teaching and learning.

Strand 8: In-service Science Teacher Education
Engineering
8:30am-10:00am, HBG Convention Center 008A
Presider: Alex T. Kararo, Purdue University

Creating Successful Middle School Teacher – Professional Engineer Partnerships To Support NGSS
Diane Silva Pimentel, University of New Hampshire
ABSTRACT:
The inclusion of engineering practices stipulated by the Next Generation Science Standards is expected at all grade levels, K-12. Most in-service science teachers have not had experience in the field of engineering and are not prepared to address these standards in their classes. Our program provides professional development focused on building partnerships between middle school STEM teachers and professional engineers based in their community to bring about the implementation of innovative approaches to engineering instruction in urban middle school classrooms. This study describes the experiences of four science teachers in the program specifically addressing how teachers chose to collaborate with their engineers throughout the school year, what challenges made the implementation of engineering standards difficult, additional supports the teachers felt would make the program more successful, and how participation in the program impacted the teachers' approach to instruction. Engagement between the teachers and professional engineers partners varied greatly by teacher. After the first year of this project, however, evidence suggests that middle school teacher-professional engineer partnerships can be one way to support teachers as they incorporate engineering standards into their classes.

Improving Professional Devlepment Experiences for Teachers Trainees in a Problem-based/Project-based Curriculum to Improve their Fidelity of Implemetation

Mary K. Nyaema, University of Iowa

ABSTRACT:
The purpose of the proposed study aims at gaining a better understanding of how the intended Project Lead the Way (PLTW) curriculum differs from the enacted curricula. This understanding is important so as to make the professional development programs more meaningful to the immediate needs of the teacher in the classroom. By identifying the factors that contribute to any merging differences between the curricula will help fill the gap in research on teacher knowledge and beliefs about science content and technology use in the PLTW classroom as they enact the curriculum. PLTW is an innovative hands on pre-engineering curriculum designed for K-12 students based on project and problem based learning. It tries to combine math and science principles to present engineering concepts to students in a way that tries to keep up with the rapid changes associated with technology in their everyday world. Multiple case sampling was used to select four teachers based on their years of teaching experience as well as background in science and math. They were interviewed about their knowledge and beliefs about project and problem based learning. Also non participant observations and teacher beliefs questionnaire were used to triangulate the data for more credible results. A fidelity of implementation rubric was also used to determine how well the teachers were implementing the curriculum. The results of the study show that teachers had moderate to high fidelity of implementation levels but was affected by how they incorporated an interdisciplinary approach in their teaching, influence of the training on their beliefs and lack of gender balance in the classroom. It is recommend to improve the professional development experiences for this teachers in order to be able to address these issues.

Investigating the Development of Elementary Teachers' Philosophy and Nature of Technology & Engineering Views
Hallie S. Edgerly, Drake University
Jaclyn M. Easter, Grand View University
Jerrid W. Kruse, Drake University
Jesse L. Wilcox, Drake University
ABSTRACT:
Elementary teachers are expected to engage in teaching engineering practice more as a result of the Next Generation Science Standards (NGSS). To do so effectively, these teachers need to have a deeper understanding of engineering and technology, with a part of this understanding being philosophy and nature of technology (PNOT). Waight and Abd-El-Khalick (2012) further contend that what is being done in teacher education programs to teach PNOT is insufficient and to the extent we are aware, no one has investigated in-service elementary teachers' PNOT views. Therefore, this project purposefully embedded aspects of PNOT into an existing grant-funded professional development program designed specifically for elementary teachers to better their teaching of science. Using a mixed-methods approach, this study brings to light the elementary teachers' PNOT views not aligned to the literature and how after the program, their views move towards alignment with PNOT literature. Participant data is used to investigate implications for supporting teachers in learning about PNOT.

The Influence of an Authentic Engineering Design Experience on Elementary Teachers' Nature of Engineering Views
Hasan Deniz, University of Nevada Las Vegas
Ezgi Yesilyurt, University of Nevada Las Vegas
Erdogan Kaya, University of Nevada, Las Vegas
Mohamed Trabia, University of Nevada, Las Vegas
ABSTRACT:
This study assessed the influence of an authentic engineering design experience on elementary teachers' nature of engineering (NOE) views across six target NOE aspects including bounded, tentative, subjective, creative and socio-cultural NOE aspects, and engineering design process. Participants were 30 elementary teachers from different schools in a large urban school district in southwestern United States. An open-ended NOE questionnaire coupled with individual interviews was used to assess participants' NOE views before and after the authentic engineering design experience. Elementary teachers participated in a 3-day professional development program that engaged them in designing soda can crushers. Engineering design experience included certain elements explicitly addressing some NOE aspects. Our data analysis indicated that elementary teachers made substantial gains in their NOE views except tentative NOE aspect. The result of the present study support the inclusion of more explicit and reflective elements to authentic engineering design experiences so that participants can further develop their NOE views.

Strand 10: Curriculum, Evaluation, and Assessment
Symposium: NGSS-Aligned Ecosystems Curriculum, PD and Assessments: What's Different This Time?
8:30am-10:00am, HBG Convention Center 006C
Presider: Suzanne M. Wilson, University of Connecticut
Discussant: Elizabeth Davis, University of Michigan
Presenters:
Anna C. MacPherson, American Museum of Natural History
Wendy M. Jackson, University of California, Berekeley
Dora E. Kastel, American Museum of Natural History
Bianca Montrosse-Moorhead, University of Connecticut
Barbara Nagle, University of California, Berkeley

Maia K. Willcox, University of California, Berkely
Suzanne M. Wilson, University of Connecticut
Elizabeth A. Davis, University of Michigan

ABSTRACT:

The Next Generation Science Standards hold promise for revolutionizing science teaching and learning in the United States. Yet to enact the vision of the standards, science instruction will need to change significantly. Knowledge has been accumulating about the best ways in which to design materials that match the NGSS vision. This symposium presents findings from one such effort—a large, collaborative, four-year project funded by the National Science Foundation. The project's goals are to design, field-test, revise, and study a 9-week middle school ecosystems unit called Disruptions in Ecosystems, PD, and assessments that align with the NGSS performance expectations. In the symposium, we will share data from two years of field-testing with middle school teachers and students in a large, urban district, and discuss revisions that were made based on feedback from teachers and research and evaluation data. The presenters will offer reflections on the ways in which the materials reflect the radically different vision of science education offered by the NGSS, and in what ways we still have room to grow, asking the critical question: does what we are doing look significantly different than what we what we were doing in curriculum, PD and assessments ten years ago? Normal 0 false false false EN-US JA X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin:0in; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:12.0pt; font-family:Cambria; mso-ascii-font-family:Cambria; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin;}

Strand 11: Cultural, Social, and Gender Issues
Increasing Engagement, Building Identity, and Narrowing Gaps
8:30am-10:00am, HBG Convention Center 008B
Presider: Mary M. Atwater, University of Georgia

Formulating a Personalized STEM Education and Career Development Plan from a Lens of Identity Development
Sheron Mark, University of Louisville

ABSTRACT:

Non-dominant populations, especially Blacks, remain disproportionately underrepresented and less successful in STEM (Valla & Williams, 2012). The "science identity gap" (Tan, Barton, Kang, & O'Neill, 2013), i.e. the difference between readily-accepted conceptions of who is/can be a STEM (science, technology, engineering, and mathematics) professional and the identities enacted by youth from their engagement in various activities and behaviors, as well as how youth see themselves in STEM, helps us understand part of the problem. This gap must be resolved in order for youth to commit to ongoing STEM participation. Furthermore, not only do non-dominant youth have less access to academic supports and resources that benefit their success in STEM, as compared to their White, middle-/upper-class peers, but the diverse/non-traditional ways in which they may enact STEM identities may be overlooked or misunderstood. This study has, therefore, aimed to apply a critical lens in examining the ways in which non-dominant youth enact meaningful and satisfying STEM identities and the ways in which these identities support future engagement in STEM, e.g. in career planning. Aiming not to generalize across populations, an in-depth, intersectional research approach was employed in examining a single case study of one male African American high school youth.

Acts of Authentication for Teen Identity Authoring in Informal learning: Examining a Research Practice Partnership
Geeta Verma, University of Colorado, Denver
Todd Campbell, University of Connecticut
TJ McKenna, University of Connecticut
Analia Villagra, Connecticut Science Center
Hank Gruner, Connecticut Science Center

ABSTRACT:

We examined a Research Practice Partnership (RPP) nested in an informal STEM program (Teen Innovation Program-TIP) at a science center. The TIP program is a multi-year program designed to engage high school students. In this proposal, we focus on underrepresented minorities (URM) who participated in the TIP program. The students develop innovative and original artifacts (e.g., museum exhibits). We created (and studied) design features and conjecture in this RPP. We focused on the jointly negotiated problem of practice, "larger social structures of formal schooling limit equitable access to STEM identity authoring/learning for URMs" in this mixed-methods study. We worked with 24 teens during the 6-week summer program (10 African American Students, 7 Latino students, 3 Asian students and 8 Caucasian students). Data sources included pre-post validated survey, participant observations, and focus group interviews. Findings suggested that various task structures (i.e., designing museum exhibits), participant structures (i.e., community of practice; paid as designers), and discourse structures (i.e., student talk; productive disciplinary engagement; leader framing) served as the mediating processes and were engaging for students for the participants. We call these high-leverage design features and argue that examining them further would support teen identity authoring in the TIP program.

Examining the Relationship between Age, Grade-Level, and Preference for Science Activities in Elementary-aged Students Grades 3-6
Angela Skeeles-Worley, University of Virginia
Robert H. Tai, University of Virginia

Ji Hoon Ryoo, University of Virginia
John T. Almarode, James Madison University
Adam V. Maltese, Indiana University

ABSTRACT:
In order to effectively address the chronic underrepresentation of women in STEM careers, we must have a more detailed understanding of the underlying causes of the problem. A question that requires closer examination is when girls' preferences for science declines. The middle-school grades are generally identified as the pivotal period when girls' interest wanes compared to their male counterparts, but further investigation is needed to pinpoint the decline. In this study, we examine girls' preferences for science activities from Grades 3-6 using regression analysis to examine the relationship of grade and gender with a preference for making/creating activities. "Creating/making" activities have been linked to science learning, and we use this measure as a possible indicator of preference for science in general. Our data consists of survey responses pertaining to learning activity preferences of 3,488 public school students in grades 3-6. We found a significant effect of gender in 6th grade on creating/making scores ($p<0.01$), but not in grades 3, 4, or 5. These results further document the shift away from a preference for science activities prior to the middle school years (as it is observable by early middle school), and highlight the need for science interventions during elementary school.

Micro-agential Steps: Measuring the Initiation of Agency within Science Classes
Zahra Hazari, Florida International University
Sanaz Farhangi, Florida International University
Geoff Potvin, Florida International University

ABSTRACT:
There has been considerable work examining the development of students' agency and its importance for challenging and reformulating traditional educational structures and students' places within those structures. However, most of these studies take place in special programs that are designed to expand students' agency and not in conventional classroom settings. We propose and examine a measure that can identify students' development of micro-agential acts which can be used to assess how each student progresses through a course towards a more robust agential position in learning science. The constructed measure for micro-agency compares students' micro-agential acts in science to their own normative acts in other school-related domains. The items include five micro-agential actions that students may take within the context of a typical science class as well as in their other classes. Data was collected for these items in introductory physics (n=60), chemistry (n=156), and biology (n=77) courses to assess the construct validity, predictive validity, and reliability of the measure. We propose that using this measure can be an easy indicator of students' development of micro-agency (initiation towards agency) for teachers and can be used by researchers to study practices that begin to promote such micro-agency development.

Science Identity as a Gateway for Engineering Professional Aspirations
UrLeaka W. Newsome, Metro Nashville Public Schools
Mary M. Atwater, University of Georgia

ABSTRACT:
The purpose of this study is to explore the development and formation of engineering identities for successful African American engineering students at Traditionally White Institutions (TWI)s. In addition, major concerns were to determine how African American engineering students exhibit their engineering identities relevant to cultural context. A qualitative case study design was used. Data were collected using semi – structured interviews, field observations, and data from memos and field notes. The purposeful sample consisted of seven African American engineering students that self – identified as a senior in academic ranking from various engineering disciplines. The findings in this study reveal that African American senior engineering students experience precursors to successfully identifying as an engineer to include embracing the role of mathematics and science identity in their understanding of engineering. In addition, a key factor in students developing an engineering identity lies in having confidence in abilities that are supported by teacher and parent social connections. Implications are posited for science teaching and science teacher training.

Strand 12: Educational Technology
Flipped and Blended Learning Environments
8:30am-10:00am, Hyatt Travis CD
Presider: Georgia Hodges, University of Georgia

A Content Analysis of Intervention Research on Flipped Classroom Studies in Engineering Courses
Ceyhan Cigdemoglu, Atilim University
Harika Ozge Arslan, Yuzuncu Yil University

ABSTRACT:
The aim of this study is to analyze the content of the intervention research conducted on flipped classroom (FC) in engineering courses. As one of the most popular teaching approach nowadays, FC studies sharply increased from year to year. Comprehensive databases of Ebscohost were searched with the keywords "flipped classroom", "inverted classroom", and "reversed classroom", 82 academic articles remained among 792 articles according to the several criteria such as being, an academic journal article, and an intervention research and conducted in STEM courses. These 82 articles (42 were conducted in mathematics, 22 in science, and 17 in engineering) were reviewed based on the selected criteria. In this paper, the analyses of articles employed in engineering courses are

reported. The findings indicate that most of the studies mainly focus on students' perceptions and achievement. Additionally, FC research in engineering is underexplored enough and research designs and methodological issues are not strong enough to make inferences about its effect on learning. Further studies are suggested to; design better experimental methods and reveal how and why FC causes better student learning.

Online Ethics Education for Science and Engineering Graduates: Introducing the C3 Instructional Model
Gizell Green
Miri Barak
ABSTRACT:
In recent years, new training programs on ethics of research were developed, providing education about responsible conduct of research (RCR) for science and engineering researchers. The literature presents a wealth of research that examines the effectiveness of different on-campus RCR programs, indicating positive results. However, it is yet uncertain whether the same positive results can be associate with online RCR training. Thus, the necessity for examining innovative models for online RCR training and verifying their educational values remains all the more important. Consequently, this study was set to conceptualize a model for online RCR education that addresses the specific needs of researchers in the field of science and engineering. The research applied the mixed methods explanatory design, with a follow-up explanation approach, in two stages. First, the study examined general expectations of novice graduate students from various STEM disciplines and research tracks regarding RCR education. Second, the study examined views about RCR training experience of graduates who completed an individual distance-learning RCR course. Findings indicated a need for a shift from individual content-centered learning to collaborative, context- and case-based (C3) learning. This study suggests an instructional model for promoting C3 learning in an online setting.

The Evidences from 10 Years Literature: A Content Analysis of Flipped Classroom Intervention Research Studies
Harika Ozge Arslan, Yuzuncu Yil University
Ceyhan Cigdemoglu, Atilim University
ABSTRACT:
This study analyzed the content of the intervention research studies conducted on flipped classroom; one of the most popular teaching approach nowadays. Comprehensive databases of Ebscohost were searched with the keywords "flipped classroom", "inverted classroom", and "reversed classroom", 82 academic articles were selected among 792 articles according to several criteria such as; being an academic journal article, an intervention research and having the subject matter in science. These 82 articles; 44 were in mathematics, 21 in science, 17 in engineering subject matters; were reviewed in detail. In the present study, findings related with the articles utilized in science disciplines (Physics, Chemistry and Biology) were reported. The results indicate that the number of flipped classroom intervention studies in science disciplines is quite low and most of the studies has been conducted in chemistry and undergraduate level. Academic performance, perceptions and opinions of the participants on flipped classroom were the most investigated dependent variables. The design details of many studies lacks in stating concrete evidences to how and why FC improve learning outcomes since neither the treatment verification nor the internal validity threats were considered. Further studies are suggested to conduct studies had stronger methodology to evaluate rigorously the impact of FC approach on learning outcomes since the findings in the literature are generally anecdotal rather than data driven.

The Impact of a Blended Learning Environment on Students Understanding: The Case of Redox Reaction
Lu Wang, University of Georgia
Georgia Hodges, University of Georgia
Tom Robertson, Cogent Education
ABSTRACT:
In this paper, we introduce a blended reality learning environment, which engages students in conducting a hands-on experiment and exploring an interactive visualization concurrently. Within this learning experience, students (n= 351) conducted a well-known lab that explores redox reaction during a chemistry class in a public high school. Results from the mixed methods study showed that students who experienced the treatment condition outperformed the business as usual (BAU) students, who conducted the lab exercise without interactive visualization. Students in the treatment condition displayed a deeper understanding of concepts as well as specific scientific practices than the BAU students. Findings suggest that blending the virtual and natural world to teach difficult concepts may improve student understanding of core concepts as well as scientific reasoning skills.

Strand 13: History, Philosophy, and Sociology of Science
Admin Symposium: International Collaborative Investigation of Beginning Seventh Grade Students' Understandings of Scientific Inquiry
8:30am-10:00am, Hyatt Presidio ABC
Discussants:
Judith Lederman, Illinois Institute of Technology
Norman Lederman, Illinois Institute of Technology
Presenters:
Mark Akubo, Florida State University

Benjamin J. Barlow, Griffith University
Selina Bartels, Illinois Institute of Technology
Estelle Blanquet, Université de Bordeaux & ESPE d'Aquitaine
Ron Blonder, Weizmann Institute of Science
Heba EL-Deghaidy, American University in Cairo, AUC
Ozgur Kivikcan Dogan, Marmara University
David Santibanez Gomez, Universidad Católica Silva Henríquez.
Jakob Gyllenpalm, Stockholm University
Soraya Hamed Al-Lal, University of Seville
Cigdem Han-Tosunoglu, Marmara University
Xiao Huang, Zhejiang Normal University
Kerstin Kremer, Kiel University
Jari Lavonen, University of Helsinki
Cheng Liu, Beijing Normal University
Enshan Liu, Beijing Normal University
Shiang-Yao Liu, National Taiwan Normal University
Rachel Mamlok, Weizmann Institute of Science
Christine V. McDonald, Griffith University
Irene Neumann, Kiel University
Yaozhen Pan, Zhejiang International Studies University
Juan Jimenez Pavez, Illinois Institute of Technology
Renee Schwartz, Georgia State University

ABSTRACT:
Although understandings about scientific inquiry (as opposed to conducting inquiry) are included in science education reform documents worldwide, little is known about what students have learned about inquiry during elementary school. This has primarily been due to the lack of an assessment instrument to measure such understandings. However, a valid and reliable assessment has recently been developed and published, Views About Scientific Inquiry (VASI). The purpose of this large scale (i.e., 19 countries and regions, spanning six continents, including 2,960 students) international project was to get the first baseline data on what beginning middle school students have learned. The participating countries and regions were: Australia, Brazil, Canada, Chile, China, Egypt, England, Finland, France, Germany, Israel, New Zealand, Nigeria, South Africa, Spain, Sweden, United States, Taiwan, and Turkey. In many countries, science is not formally taught until middle school, which is the rationale for choosing seventh grade students for this investigation. This baseline data will simultaneously provide information on what students have learned about inquiry in elementary school, as well as their beginning knowledge as they enter secondary school. A follow-up study involving high school teachers is planned to see what students have learned as they proceed through secondary school. It is important to note that collecting data from every one of the 130+ countries and regions globally was not humanly possible, and it was also not possible to collect data from every locale of each country and region. A concerted effort was made, however, to provide a relatively representative picture of each country and region and the world.

Strand 14: Environmental Education
Related Paper Set: Measuring Environmental Behaviors, Knowledge, and Attitudes
8:30am-10:00am, HBG Convention Center 006A
Presider: Keith R. Langenhoven, University of the Western Cape

ABSTRACT:
The Competence Model has been described as a promising environmental behavior model that 1) addresses and maintains past findings of environmental behavior research by focusing on the constructs of environmental behaviors, knowledge, and attitudes; 2) is intended for use in the development of environmental learning programs; and 3) can be statistically tested (Kaiser, Röczen, & Bogner, 2008). The model describes how specific predictors (knowledge and attitudes) influence pro-environmental behaviors (Roczen, Kaiser, Bogner, & Wilson, 2013). The purpose of this study was to test the reliability and validity of two new measurement tools, the Revised General Environmental Behaviors (GEB) scale and Expanded Ecological Concepts Questionnaire (ECQ), for use in the Competence Model. Exploratory Factor Analysis, Confirmatory Factor Analysis and Classical Test Theory analysis techniques were used to explore the quality of the instruments. Results indicate high reliability and validity for the GEB scale, while the results suggest the need for further testing and model modification.

Toward Pollinator Conservation – Acquiring Environmental Relevant Knowledge about Bees
Kerstin Bissinger, University of Bayreuth
Christine J. Thorn, University of Bayreuth
Mona L. Schönfelder, University of Bayreuth
Franz X. Bogner, University of Bayreuth

How Individual Environmental Attitudes Predict Cognitive Knowledge in Nature Conservation
Kerstin Bissinger, University of Bayreuth
Christine J. Thorn, University of Bayreuth
Mona L. Schönfelder, University of Bayreuth
Franz X. Bogner, University of Bayreuth

Fostering Environmental Literacy by an IBSE-approach
Kerstin Bissinger, University of Bayreuth
Christine J. Thorn, University of Bayreuth
Mona L. Schönfelder, University of Bayreuth
Franz X. Bogner, University of Bayreuth

Measuring Key Components of the Competence Model for Environmental Education
Lisa D. Felix, University of Arizona
Bruce Johnson, University of Arizona
Sanlyn Buxner, University of Arizona
Constantinos C. Manoli, Universtiy of Arizona

Strand 15: Policy
Related Paper Set: Organizing for Multi-State Educational Improvement in Science Education
8:30am-10:00am, Hyatt Seguin AB
Discussant: Richard Duschl, Pennsylvania State University
ABSTRACT:
We explore findings from the first year of a project to build foundational knowledge about the role that state agencies can play in supporting improvement to science education when partnered with researchers and networked with each other. The project is a partnership between the professional association of state science supervisors and two universities. State science supervisors from 13 states formed teams and a network to develop and test state-level strategies and resources for improving formative assessment as a policy instrument for aligning curriculum, instruction, and assessment. The strategies and resources are shared with state science education staff from across all the country. We aim to build knowledge and theory about the conditions under which a network of state teams can promote coherent guidance for instruction in local districts and schools. We engage in design-based implementation research to investigate how we can support the equitable implementation the "3-dimensional" model of science and engineering learning that integrates disciplinary core ideas, science and engineering practices, and crosscutting concepts. The central problem we investigate is developing knowledge about the conditions under which coherent state systems of science education can emerge in which all students have opportunities to meet challenging new standards.

Redesigning Infrastructures for Tailored Instructional Improvement: A Networked Improvement Community for State Science Education
William R. Penuel, University of Colorado
Philip L. Bell, University of Washington
Sam Shaw, South Dakota Department of Education
Tiffany Neill, Oklahoma State Department of Education
Richard A. Duschl, Pennsylvania State University

Influence Maps: A Strategy for Improving Vertical Coherence in State Science Education
Robbin Riedy, University of Colorado Boulder
Katie Van Horne, University of Colorado, Boulder
William R. Penuel, University of Colorado
Philip L. Bell, University of Washington
Sam Shaw, South Dakota Department of Education
Tiffany Neill, Oklahoma State Department of Education

Teacher Vision of Science Education: One Measure of Vertical Coherence
Joanna Weidler-Lewis, University of Colorado, Boulder
Rebecca Kaplan, University of Colorado, Boulder
Katie Van Horne, University of Colorado, Boulder
William R. Penuel, University of Colorado

Collaborative Design Practices of a Research-Practice Partnership Supporting State-level Educational Improvement

Philip L. Bell, University of Washington
Shelley Stromholt, University of Washington

Concurrent Session #4
10:15am – 11:45am

Presidential Sponsored Session
Admin Symposium: Global and Local Social, Cultural, Language, and Political Aspects for Science Education
10:15am-11:45am, Seguin AB
Presider: Mei-Hung Chiu, National Taiwan Normal University
Discussant: Larry Yore, USA
Presenters:
Larry Bencze, Canada
Lyn Carter, Australia
Sonya Martin, Korea
Christina Siry, Luxembourg
Hsiao-Lin Tuan, Taiwan
Jinwoong Song, Korea
Jiyeon Na, Korea
ABSTRACT:
This session intends to bring international researchers to discuss how to link global trend of science education research and practice with local (contextual) needs. Larry Bencze and Lyn Carter discuss needs for educators to share with students socio-political considerations as they relate, locally and globally, to relationships among powerful individuals and groups and fields of science, technology, engineering and mathematics and to encourage and enable students to actively address their concerns about such relationships. Sonya Martin and Christina Siry discuss findings from research on science teaching and learning in multilingual and multicultural contexts that highlight both the relationships and disconnects from science education research from local contexts to those in the global contexts and vice versa. They make recommendations about ways that researchers can learn from international research findings while still paying attention to the locally contextualized nature of engaging in science education. Hsiao-Lin Tuan who present research published by various Taiwanese scholars and several local projects to reflect upon the global and local impacts of science education. Jinwoong Song and Jiyeon Na based on their recent projects. They explain how science classroom interactions in Korea (e.g. classroom culture, silent participation) are shaped by East Asian cultures and talk about the potential of using technology-based approaches in response to new glocal changes.

Publications Advisory Committee Sponsored Session
Admin Symposium: The JRST Doctoral Student Mentored Reviewer Initiative: Bolstering a Top-Tier Research Journal's Graduate Education Contributions
10:15am-11:45am, Hyatt Republic ABC
Presenters:
Fouad Abd-El-Khalick, University of North Carolina
Dana L. Zeidler, University of South Florida
ABSTRACT:
JRST will present a new initiative aimed to engage doctoral students firsthand with the peer-review process, realizing JRST's potential as an effective instrument for professional development. A faculty member from the broader science education community may request that a small number (2 to 5) of his/her doctoral advisees serve as JRST Mentored Reviewers. The students will be invited to write reviews for a manuscript currently under JRST review. While these will not count toward the final manuscript decision, the Doctoral Student Mentored Reviewers will examine, and compare their own reviews with, 'official' reviews and resultant editorial decision letter. The sponsoring faculty member will—as part of the process—lead student discussion about the reviews, decision, and ways to respond to recommendations for revision and manuscript improvement. Once the student group submits a synthesis report of these discussions—endorsed by the faculty member—to the JRST editorial office, a formal letter will acknowledge the student and faculty roles, and they will also be cited in the corresponding year-end JRST issue. This symposium will explain the initiative, elicit student and faculty feedback, and engage participants in discussion on writing effective and informative manuscript reviews for JRST.

Strand 1: Science Learning, Understanding and Conceptual Change
Teaching and Learning of Energy as a Cross-Cutting Concept
10:15am-11:45am, HBG Convention Center 006D
Presider: Italo Testa, University Federico II Napoli

Student Conceptualization of Wind Energy Issues and Their Decision-Making in Wind Energy Education
Ashley Peterson, University of Nebraska, Lincoln
Cory T. Forbes, University of Nebraska, Lincoln
ABSTRACT:
Socio-scientific issues (SSIs) represent challenges at the intersection of science and everyday life that require students to use scientific knowledge, argumentation skills, personal values, and morals to articulate science-informed decisions. Wind energy is an important and highly-relevant SSI around which little research has been conducted, especially in K-8 settings. A students' initial 'framing' of a SSI has the potential to contribute substantially to solutions they propose and decisions they make. However, very little is known about how middle school students conceptualize wind energy SSIs, particularly how they problematize their scientific and social dimensions. To address this need, we developed a multi-week mini-unit around the proposed local development of a large wind farm in collaboration with three 6th-grade teachers who, in turn, implemented the unit with their students. Here, we analyze student artifacts (n=116) to better understand reasoning about the wind energy SSI on a continuum of concrete to abstract using Construal Level Theory, which suggests concrete thinkers will focus on feasibility issues whereas abstract thinkers will focus on desirable outcomes. Understanding the implications of concrete and abstract thinking about this wind energy SSI has implications for improving science literacy.

Korean Secondary Students' Learning Progression of Energy Concepts across Physical and Biological Contexts: A Connection to the Curriculum
Nam-Hwa Kang, Korea National University of Education
ABSTRACT:
The purpose of this study was to examine how students develop an understanding of the concept of energy across disciplines by examining LPs of secondary students in South Korea. We have developed short scenarios of everyday events that included 6 energy forms that are in the curriculum for Korean middle school students. For each scenario, students were asked to respond to two open-ended questions that required them to describe an energy chain and to determine changes of the total amount of energy in the system. Responses from a total of 212 middle and high school students were analyzed based on 4 levels of understanding—recognition of energy forms, partial understanding of transfer and transformation, full understanding of energy transform, and full understanding of energy conservation. Using partial credit Rasch modeling method students' LP was examined. Findings showed that there was a developmental trend across grades while the average scores were relatively low in all grades. When we examined item fit statistics, we found that the hypothetical progression model of this study was appropriate. A Wright map of the data demonstrated that understanding of energy conservation is too challenging even to high school students. Further research topics are discussed.

A Cognitive Scaffold for Teaching Energy Transfer between Systems in Middle School
Marcus Kubsch, Leibniz Institute, Kiel
Jeffrey Nordine, Leibniz Institute, Kiel
ABSTRACT:
Energy is an important topic in everyday life and one of the most central ideas in science, which is reflected in standards documents such as the Next Generation Science Standards (NGSS). However, a wide range of studies have revealed that students struggle to see energy's value in predicting an explaining phenomena. As part of a project that has developed a curriculum that emphasizes energy transfers between interacting systems (as the NGSS suggests), we have developed a new representation that serves as a cognitive tool, called the Energy Transfer Model (ETM), to help students model, predict, and explain phenomena from an energy systems-transfer perspective. We conducted an interview study during the pilot enactment of the curriculum in which students (N=30) were asked to explain novel phenomena using a systems-transfer perspective. Half of the interviewed students were asked to construct an ETM to support their explanation the other half was not. Results indicate that while most students used the systems-transfer perspective successfully, students who were prompted to create an ETM were able to reason more productively about novel phenomena (e.g., speculate that unobservable processes must be occurring) than students who did not construct an ETM.

Leveraging Students Prior Knowledge to Adapt Science Curricula to Local Context
Lana Minshew, University of North Carolina, Chapel Hill
Kelly Barber-Lester, University of North Carolina, Chapel Hill
Sharon Derry, University of North Carolina, Chapel Hill
Janice L. Anderson, University of North Carolina, Chapel Hill
ABSTRACT:
Conceptions of ecological processes such as the flow of energy and cycling of matter in an ecosystem are becoming important understandings in a changing world. Research for this study was conducted in the context of Biosphere, a federally funded Design Based Research (DBR) project. The Biosphere project aims to develop "Compost", a collaborative, inquiry biology curricular unit focused on sustainability issues and suitable for under-resourced middle schools in rural areas in the United States. Utilizing a p-prims or knowledge in pieces lens has allowed our team to look for current understandings and disconnects in students' prior conceptualizations, specific to our context, which we can now utilize to make adaptations and changes to our next iteration of curricular design.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Student Interests and Motivations
10:15am-11:45am, HBG Convention Center 007A
Presider: Claudia P. Aguirre-Mendez, Emporia State University

Gamification and the Enhancement of Motivation to Learn Biology in an Introductory Undergraduate Laboratory Course
David Owens, Middle Tennessee State University
Angela Barlow, Middle Tennessee State University
Cindi Smith-Walters, Middle Tennessee State University
Eric Oslund, Middle Tennessee State University
Dennis Mullen, Middle Tennessee State University
ABSTRACT:
Proponents of gamification suggest that the inclusion of elements of video game design, such as leaderboard with badges and repeat-testing, can enhance motivational outcomes in formal learning environments. The inclusion of leaderboard with badges, which emphasize social comparison, induce performance classroom goal structures, while trial-and-error learning that includes feedback, which is characteristic of repeat-testing, exemplifies a mastery classroom goal structure. Whether the inclusion of performance classroom goal structures results in adaptive motivational outcomes has been debated. Eight laboratory sections of a second semester introductory undergraduate biology laboratory course, including 140 students, were randomly assigned to either control, gamified, repeat-testing, or gamified with repeat-testing treatments. The gamified with repeat-testing treatment stabilized students' motivation to learn biology. Conversely, motivation to learn biology significantly decreased in control, gamified, and repeat-testing groups. Motivation to learn biology was significantly greater in the gamified with repeat-testing group than in control or gamified groups. These results suggest that gamification can enhance motivation, and lend support to the multiple goal perspective, where performance and mastery classroom goal structures can aid in the enhancement of motivation to learn biology. Implications for implementation and future direction for study are discussed.

Modeling Changes to Students' Motivation for Science in Schools that Serve Low SES Communities
Israel Touitou, Weizmann Institute of Science
David L. Fortus, Weizmann Institute of Science
ABSTRACT:
Students' mastery goals orientation in science plays a central role in the fruitfulness of their time spent studying science at school. Students that have adopted mastery achievement goals in science are more likely to be persistent, challenge-oriented, self-regulated, and have high self-efficacy as science learners. However, except in non-traditional settings, research has demonstrated that students' mastery goals orientation in science declines towards the end of elementary school and during the middle school years. In schools serving low socio-economic populations, this problem is compounded by the lack of resources and general issues with students' stereotypical mental images of their selves. Research on motivation has traditionally looked at the relations between environmental factors (school, science teacher, parents and peers) and the state of individuals' mastery orientation. In my work, I propose using the change over a year to a student's mastery goal orientation ($\delta m/\delta t$) as the indicator of the effect of the environment on a student. The goal of this study was to characterize the environmental factors that influence the mastery orientation in science of students from low SES backgrounds to engage in science learning and to use them to model changes to students' mastery orientation.

Motivational Beliefs in Science Learning and School Motivational Contexts: Evidence of Taiwanese TIMSS Eighth-grade Data
Chen-Lung Wang, National Central University
Pey-Yan Liou, National Central University
ABSTRACT:
Taiwanese students have featured as having high academic achievement but low motivational beliefs in a series of the Trends in Mathematics and Science Study (TIMSS), especially eighth-grade students. Moreover, given that the role of context has become more important in the academic motivation theory, this study aims to explore the relationship between motivational beliefs and science achievement at both the student and school levels. Self-concept, intrinsic value, and utility value are based on the expectancy-value theory proposed by Eccles and her colleagues. A two-level hierarchical linear model was adopted to analyze the Taiwanese TIMSS 2011 eighth-grade science data, with the results indicating that each motivational belief positively predicts on science achievement. It suggested that teachers can probably improve students' science achievement through cultivating their motivational beliefs. Additionally, a positive school contextual effect of self-concept on science achievement was identified, meaning that, improving students' self-concept may improve science achievement, not only as a result of their own learning process but also of positive social interaction. Regarding the cross-level interaction, school-mean utility value had a negative moderating effect on the relationship between utility value and science achievement. Overall, school plays a prominent role in students' motivational beliefs in science learning.

Network Centrality in Interactive Physics Classes Facilitates Changes in Physics Interest Via Students' Self-efficacy
Remy Dou, Florida International University

Eric Brewe, Florida International University
Geoff Potvin, Florida International University
Justyna P. Zwolak, Florida International University

ABSTRACT:
The proliferation of active-learning pedagogies serves as part of the response to national calls for an increased number of students pursuing STEM careers. Research studies on these teaching approaches often cite improved student academic performance, yet this variable is typically not the primary contributor to students' career decision-making. Two prominent career theories—the Social Cognitive Career Theory (SCCT) and the career identity framework—posit that domain specific interest and constructs related to self-efficacy play more crucial roles in students' career choices. This has been shown in a variety of STEM domains, including physics. Given that increased student interactions is a salient characteristic of active-learning pedagogies, we examine the effect of these on both students' physics self-efficacy and physics interest in an active-learning, discourse-based undergraduate introductory physics course at a Hispanic Serving Institution. We test a structural equation model to determine the contribution of student interactions to these constructs, quantifying interactions using network analysis techniques. We find that PageRank centrality— a measure that captures participants' academic popularity based on the academic popularity of their peers—indirectly contributes to physics interest via changes in physics self-efficacy, concluding that class-related interactions in active-learning environments positively shape self-efficacy and interest formation.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Integrated Science Approaches
10:15am-11:45am, Hyatt Crockett CD
Presider: Ceyhan Cigdemoglu, Atilim University

"Using Your Brain to Figure It Out": Transitioning to the Reform Science Classroom
Aliza Stein, Northwestern University
Brian J. Reiser, Northwestern University
ABSTRACT:
As science classrooms are reformed to involve learners in science practices, these new classroom interactions require dramatic shifts for many science classrooms. This shift in classroom norms requires students to change both how they engage in the science classroom and how they understand their role as an epistemic agent in the knowledge-building of the classroom. This paper utilizes two classrooms that are implementing a reform science learning environment for the first time as case studies. In one class, students not only deeply engage in the communal construction of scientific explanations, but they also celebrate their epistemic authority in their classroom. In the second class, students do not display episodes of productive disciplinary engagement as often and they resent the epistemic authority that they have received. These disparate reactions emphasize the importance of looking at both students' epistemic practices and their epistemic beliefs when supporting students' transition to the reform science classroom.

Achievements in Science Reading Literacy: The Science Literacy and Literacy in Science Relationship
Billy Mcclune, Queen's University
ABSTRACT:
This paper reports on a study of a curricular intervention for pupils (age 11-14 years) in the UK aimed at developing critical reading literacy using science based media reports. In particular the study focused on core reading literacy elements of accessing information, interpreting text and evaluating and responding critically to science based media reports. Competency tasks were used to assess pupils' capability as critical consumers of science presented as news. This was an empirical study based on classroom observation. Data included assessment tasks, questionnaires and semi-structured interviews with pupils. In addition, video recording of group activity and intentional conversations between pupils were scrutinised. Pupils demonstrated a grasp of all elements of critical reading however their mastery of higher-level elements was limited. Competency in these skill areas was best illustrated in the context of collaborative working. Normal 0 false false false EN-US JA X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0cm 5.4pt 0cm 5.4pt; mso-para-margin:0cm; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:12.0pt; font-family:Cambria; mso-ascii-font-family:Cambria; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin; mso-ansi-language:EN-US;}

Exploring the Significant Predictors of Student Creative Science Thinking Performance
Kuay-Keng Yang, National Sun Yat-Sen University
Ling Lee, National Sun Yat-Sen University
Zuway-R Hong, National Sun Yat-Sen University
Huann-Shyang Lin, National Sun Yat-Sen University
ABSTRACT:
This study investigated how students' Awareness of Creativity Learning Environment in science classroom (ACLE), competency of Science Inquiry (SI), and Science Achievement (SA) are related to their performance on Scientific Creativity (SC) (including divergent and convergent creativity). Using a sample of 307 elementary students (N = 100 for 5th grader and 207 for 6th graders) from four elementary schools with similar background, a model was obtained. Three instruments: ACLE scale, new Scientific Creative Test

(n-SCT), and M-Inquiry test (M-inquiry) were used and the scores of students' SA were acquired from their own schools. The analysis of structural equation modeling revealed that ACLE, SI and SA had significant effect on student's performance of SC. When focusing on the constructs of SC, divergent and convergent creativity separately, the result revealed that ACLE, SI and SA had significant direct effect on divergent creativity but there was no significant effect on convergent creativity except the factor of SI. This specific result illuminated the critical mediating role of science inquiry in promoting student scientific creativity. The implication of science teaching will be discussed. Keywords: creative science thinking, competency of science inquiry

Integrated Science and Literacy K-12 Instruction: A Meta-analysis
Jennifer C. Parrish, Middle Tennessee State University
Summer Talbert, Middle Tennessee State University
ABSTRACT:
The purpose of this meta-analysis was to examine the extant literature and determine the effectiveness of integrated K-12 science and literacy instruction on student achievement in both content areas. A total of 23 studies met the inclusion criteria. The overall effect for literacy outcomes was small (ES = 0.36) but moderate for science outcomes (ES = 0.61) when science and literacy instruction was integrated. Findings from a moderator analysis indicated there may be contextual factors that science educators should consider as they design and implement integrated K-12 science and literacy instruction. Having text as the central focus during science learning may be an important predictor of both literacy and science outcomes and integrated instruction that required students to integrate information across multiple text sources was associated with smaller effects. Future studies should consider how to effectively select and use science texts as well as determine the best teaching strategies for using multiple text sources. In addition, research should further examine the use of metacognitive strategies and inclusion of multiple NGSS science and engineering practices in integrated science and literacy instruction.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Symposium: Results of the PCK Summit 2016: Five Approaches for Capturing PCK
10:15am-11:45am, HBG Convention Center 007B
Discussant: Alicia C. Alonzo, Michigan State University
Presenters:
Erik Barendsen, Radboud University Nijmegen
Ineke Henze, Radboud University, Nymegen
Pernilla Nilsson, Halmstad University
Dürdane Bayram-Jacobs, Delft University of Technology
Sven Liepertz, University of Potsdam
Andreas Borowski, University of Potsdam
Kirsten Daehler, WestEd
Joan I. Heller, Heller Research Associates
Nicole Wong, Heller Research Associates
ABSTRACT:
The idea of pedagogical content knowledge (PCK) was introduced by Shulman (1987) as the missing paradigm in research on teacher knowledge. Since then several PCK models were proposed, with the Magnusson model being the most cited (Magnusson, Krajcik, & Borko, 1999). A teacher's professional knowledge is difficult to categorize and therefore, difficult to articulate and record (Loughran, Mulhall & Berry, 2004). As Baxter and Lederman (1999) noted, PCK is a highly complex construct that is not easily assessed. Based on the work of an international PCK Summit, Gess-Newson (2015) articulates a model of teacher professional knowledge and skill that is used during and surrounding instruction.. While these PCK models establish strong frameworks for research, they point out that capturing PCK is complex and requires a combination of approaches and instruments. The presenters of this Symposium participated in a second international PCK Summit and present five different approaches to capturing in-service and/or pre-service science teachers' PCK. The efforts of these five research teams illustrate the complexity of the task and offer a springboard for discussion on the topic of assessing teacher PCK in relation to science instruction.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Poster Symposium: Supporting Three-dimensional Science Teaching and Learning with a Comprehensive, Learning Progression-based System
10:15am-11:45am, Hyatt Presidio ABC
Discussant: William Penuel, University of Colorado
ABSTRACT:
The posters in this session report data from a design-based implementation research (DBIR) project focusing on carbon cycling at multiple scales at the middle- and high-school level. The research reported here focuses on "three legs of a stool" for improving teaching and learning (a) curriculum and assessments, (b) online and face-to-face professional development (PD), and (c) professional support networks. Each of these components is necessary but not sufficient to support rigorous and responsive teaching leading to three-dimensional science learning. The posters in this session focus on all three components and relationships among them for 34 participating teachers and their students. Posters 1 and 2 use student interview and written assessment data to investigate relationships

among students' explanations of macro-scale phenomena, arguments from evidence about investigations, and explanations of global carbon cycling. Posters 3 and 4 use video and interview data from case study classrooms and student work to investigate classroom discourse and its effects on student learning. Posters 5, 6, and 7 use survey and interview data from teachers, as well as videos and field notes from professional development, to investigate relationships among teachers' agency, sensemaking, participation in professional networks, and classroom practices.

The Relationship between Students' Explanations and their Interpretation of Inquiry Investigations
Emily Scott, Michigan State University
Charles W. Anderson, Michigan State University

An Initial Learning Progression Describing Students' Understanding of a Model of the Global Carbon Cycle
Joyce M. Parker, Michigan State University
Beth A. Covitt, University of Montana
May Lee, Michigan State University
Charles W. Anderson, Michigan State University

An Examination of Discourse in Carbon TIME Classrooms
Wendy Johnson, Michigan State University
Hannah Miller, Johnson State College
Charles W. Anderson, Michigan State University

Routines of Interaction around Carbon TIME Tools that Enhance Student Learning
MaryMargaret Welch, Seattle Public Schools
Jennifer Newell, Seattle Public Schools
Christa Haverly, Michigan State University
Marcos Gonzalez, Michigan State University

The Influence of Social Networks and Context on Teacher Agency
Stefanie Marshall, Michigan State University
William R. Penuel, University of Colorado
Qinyun Lin, Michigan State University

Teachers' Sensemaking About Innovative Curriculum Materials
Elizabeth Xeng de los Santos, Michigan State University
Charles W. Anderson, Michigan State University

Using Survey Data to Measure Teaching Practices and Network Effects in Carbon TIME
Qinyun Lin, Michigan State University
William R. Penuel, University of Colorado
Kenneth A. Frank, Michigan State University

Strand 5: College Science Teaching and Learning (Grades 13-20)
Physics - Problem Solving and Instruction
10:15am-11:45am, HBG Convention Center 007C
Presider: Muhsin Menekse, Purdue University

An Analysis of Discussion Quality in LA-Supported Group Physics Problem Solving
Alaina Pak, George Washington University
Tiffanyrose Sikorski, George Washington University
ABSTRACT:
There has been a growing push in universities to acknowledge and increase student involvement and discussion as an integral part of the learning process. At least 88 universities have adopted the Colorado-Boulder Learning Assistant Program, which trained undergraduate students in classrooms to help facilitate group problem-solving and discussion. This study examines LA effectiveness by comparing the quality of group discussions with and without LA facilitation in the context of an introductory physics course. Before LA involvement, students were off-topic or silent in nearly half of the relevant clips. During LA presence, students asked on-topic questions and explained their reasoning. Though LAs did not give answers, they favored questioning strategies that funneled students to particular answers as opposed to strategies that encouraged collaboration. Immediately following LA interactions, the professor often continued with class, by nature of the class structure and timing. When this was not the case, however, students tended to work through the remaining parts of the problem or clarify points of confusion. These findings suggest that although places for improvement exist, LAs effectively facilitate discussion by directing students' attention to their reasoning about the task.

Effect of Visual Cues and Video Solutions on Eye-gaze Patterns
Tianlong Zu, Purdue University
Elise Agra, University of Chicago
John Hutson, Kansas State University
Lester Loschky, Kansas State University
N. Sanjay Rebello, Purdue University
ABSTRACT:
With the advent of online learning systems, the use of multimedia instruction is becoming ubiquitous. However, there has not been significant research on the effect of multimedia instruction on eye movements and its implication for physics problems solving. In this study we investigate two different conditions for improving problem solving and transfer on conceptual physics tasks. In each condition, students first solved an initial task and then completed a computerized training session based on the condition. Finally, each student completed a near transfer and a far transfer task. The training session conditions used either guided instruction with a video solution or semi-guided instruction with visual cues. We compare the eye movement patterns and task performance in both conditions.

Impact of Mathematical Complexity on Students' Conceptual Performance in Sequential and Simultaneous Synthesis Physics Problems
Bashirah Ibrahim, The Ohio State University
Lin Ding, The Ohio State University
ABSTRACT:
We explore the effect of mathematical complexity on students' conceptual performance in sequential and simultaneous synthesis problems. Sequential problems require the chronological application of pertinent concepts. Simultaneous problems require the concurrent application of fundamental concepts. Mathematical complexity refers to the number and the type of equations that are solved concurrently. Conceptual performance pertains to the identification, follow-up and correct application of the pertinent concepts. Data were collected from written tasks and individual interviews administered to students from a second year calculus-based physics course. Results indicate that mathematical complexity does not impact students' conceptual performance on the sequential tasks. However, it has negative influences for the simultaneous problems. This may be due to the students' familiarity and confidence in particular concepts coupled with cognitive load associated with tackling complex mathematical formalism. These outcomes have important implications for applying learnt principles and assessing students' conceptual understanding.

What's Important: An Analysis of Student Comments on Physics Professors on RateMyProfessors.com
Mihwa Park, University at Buffalo, SUNY
ABSTRACT:
This study aims to analyze students' ratings and comments on their introductory physics professors, in the United States, posted at RateMyProfessors.com. Data was obtained from students' evaluations of 64 introductory physics professors from 15 research universities in the United States posted at RMP. Students' numerical overall quality ratings were also obtained along with students' commentaries. 1554 students' comments were grouped into (1) comments rated with Good quality, (2) comments rated with Average quality, and (3) comments rated with Poor quality. Students' written responses were analyzed by extracting terms and phrases using IBM SPSS modeler with Text Analytics. Extracted terms and phrases were then grouped into categories which represent a homogenous concept. The categories and numerical ratings were used to build a decision tree to select important categories to predict numerical professors' qualities from students' comments. The results showed that students were more sensitive to their professors' classroom practices, teaching strategies, and how they treated students, than they were to the required work for students (homework, taking exams etc.), professors' personal characteristics such as foreign accents, or extra credit provided for students' benefit.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers' PCK
10:15am-11:45am, HBG Convention Center 007D
Presider: Mark A. McDermott, University of Iowa
ABSTRACT:

Model-Based Inquiry into Prospective Teachers' Topic–Specific Pedagogical Content Knowledge for Teaching Dissolving
Karthigeyan Subramaniam, University of North Texas
ABSTRACT:
This proposal details the findings of a study that analyzed prospective teachers' use of verbal models and visual models – representation models (De Jong, Blonder & Oversby, 2013) - to teach the concept of dissolving utilizing the model-based inquiry format (Campbell & Neilson, 2012; Campbell, Oh & Neilson, 2012). The study aimed to explicate prospective teachers' pedagogical content knowledge from their use of the aforementioned representation models to teach the concept of dissolving. Four sets of data were collected: (1) transcripts (2) field notes (3) transcripts of focus groups interviews, and (4) written artifacts. In accordance with the model-based inquiry format and the unified vision of model-based teaching (MBT), and model-based inquiry (MBI) framework, a discourse mode analysis framework (Campbell et al. 2012a; Oh 2005) was used to analyze the data and employed by all participants

were procedural drawings and none contained drawings of how the salt dissolves in water, hydration shells, etc. Verbal models such as oral expressions and written texts that exemplified their explanations of how salt dissolves in water were present in their science notebooks and dialogues but these were also limited to the steps of dissolving the salt in water: the procedure.

Domain Specific Facets of Pre-Service Teachers' Academic Self-Concept
Markus Elsholz, University of Wuerzburg
Thomas Trefzger, University of Wuerzburg
Susanne Kuger, German Institute for International Educational Research
ABSTRACT:
This study aims to provide empirical insights in pre-service teachers' academic self-concept. Three differentiable facets of self-concept are proposed which reflect basic domains of a standards university teacher training and their later teacher profession (i.e. content knowledge CK, pedagogical content knowledge PCK and pedagogical knowledge PK; Shulman, 1986). This corresponds to the well known multidimensionality and domain specificity of self-concept (Marsh & Hattie, 1996). Consideration of self-concept in the context of academic learning is crucial to maximize academic outcome and performance (Marsh, 2006). Academic self-concept was operationalized and assessed from N=114 pre-service teachers who had already completed about one half of their university studies. Latent three factor models of academic self-concept were tested by confirmatory factor analysis. Fit indices indicate good model fit. Regression analyses show significant and plausible relations of gender, prior teaching practice, prior academic outcome and school course selection to the self-concept ratings which further supports the validity of the three factor approach.

Investigating the Relationship of Pre-service Physics Teachers CK and PCK with Academic Self-concept
Stefan Sorge, Leibniz Institute for Science and Mathematics Education, Kiel
Knut Neumann, Leibniz Institute for Science and Mathematics Education, Kiel
Jens Möller, University of Kiel
ABSTRACT:
Science teachers' generalized professional knowledge is considered as an important prerequisite for high quality instruction. According to Shulman such generalized professional knowledge bases include Content Knowledge (CK) and Pedagogical Content Knowledge (PCK). However, recent research produced mixed results regarding the structure of these knowledge bases and therefore a sounder theoretical and empirical foundation is needed. The Dimensional Comparison Theory (DCT) is a well-tested theory explaining the impact the comparison of an individual's ability in two different domains has on the respected self-concept dimensions. In order to investigate the DCT of pre-service physics teachers' professional knowledge, we examined the CK, PCK and the respective self-concept dimensions of N = 201 pre-service physics teachers from 12 teacher education institutes in Germany. To examine the DCT we utilized a structural equation approach. Our results not only suggest that CK and PCK positively impact their respective self-concept dimension, but also that pre-service physics teachers with a given level of PCK have a lower self-concept of PCK if their CK level is higher. Finally, we discuss potential benefits from combining research on professional knowledge and on DCT for science education research.

The Development and Application of PCK by Per-service Teachers in the Student Lab
Susan Fried, University Wuerzburg
Thomas Trefzger, University of Wuerzburg
ABSTRACT:
Practical training is an important part of pre-service teacher education. In Germany the student-labs become a new way of practical training courses. The student-lab courses at the University of Würzburg is implemented in the pre-service teacher education since 2010. In the course the pre-service teachers set up experimental stations for a given teaching unit. Following this, three to four school classes are invited to perform the lab. Subsequent to every performance the pre-service teachers reflect their teaching with the instructors and the peer group. Interest of our research is the professionalization through practical training. Therefore we would like to know whether the pedagogical content knowledge (PCK) of the pre-service teachers developed during the course. In addition, the survey focuses on the knowledge applied by the pre-service teachers for designing the experiments and the conduct with school-classes. To survey the PCK two questionnaires are used based on the project KiL by the IPN Kiel and on the project DIAGNOSER by the NSF and the University of Washington. To analyse the knowledge they applied during the student-lab course the pre-service teachers keep a journal. In my talk I will present the final-results of the survey.

Strand 8: In-service Science Teacher Education
Inquiry
10:15am-11:45am, HBG Convention Center 008A
Presider: Sarah R. Stapleton, University of Oregon
ABSTRACT:

Changing Teacher Values about Science Instruction: Cumulative Influences of a Research Experience and Materials Development
Senetta F. Bancroft, Southern Illinois University, Carbondale
Deborah G. Herrington, Grand Valley State University

Molly M. Edwards, Grand Valley State University
Stephanie Tanis, Grand Valley State University

ABSTRACT:

Although changing teacher beliefs is challenging, effective professional development (PD) remains the most promising strategy to support instructional reform. A previous study exploring how a research experiences for teachers, the first of three core experiences in a two and half year PD program, changed in-service, middle and high school science teachers' beliefs about inquiry-based instruction showed a small subset of teachers underwent a belief change so profound it was characterized as a value change. A value change was characterized by teachers revising all activities to better align to inquiry, expressing strong pedagogical content knowledge, and describing an urgent internal imperative that led them to seek out and support science teachers within their building to adopt inquiry-based practices. This qualitative study was a further exploration of how participating teachers' beliefs progressed after the second core experience, the materials adaptation. This presentation details changes in teachers' beliefs using interview data from author created items and items from validated science teacher beliefs instruments. The PD program features teachers identified as influential to changing their values about science instruction are also presented.

Classroom Patterns that Characterize the Different Levels of Inquiry Instruction

Daniel M. Alston, The University of North Carolina, Charlotte
Jeff C. Marshall, Clemson University
Julie B. Smart

ABSTRACT:

In the United States, reform movements have been a part of the science education community for decades. Inquiry-based instruction has a long history in reform documents and while it is not explicitly used in the Next Generation Science Standards (NGSS), the underlying tenants of this instructional strategy are still evident. Thus, inquiry-based instruction remains a strategy that science teachers can use to address the expectations set forth in the NGSS. Therefore, it is crucial that researchers provide science teachers with information concerning the characteristics their inquiry-based lessons should exhibit. This study utilized 5 years of data collected on inquiry-based lessons to search for distinctive patterns between at least proficient and below proficient lessons. Specifically, we sought to describe these patterns in terms of the amount of time spent in the different components of inquiry and levels of student cognitive engagement. We ran ANOVAs to determine if distinct patterns existed. Results showed that at least proficient inquiry lessons spent more time allowing students to explore scientific concepts and getting students to display higher-order thinking skills. Implications of these findings speak to at least proficient inquiry instruction being a viable instructional strategy to accomplish the goals set forth in the NGSS.

Examining Inservice Teachers' Metamodeling Knowledge

Kirsten K. Mawyer, University of Hawaii

ABSTRACT:

The Framework and NGSS conceptualize science inquiry learning as engaging in scientific practices including the practice of scientific modeling. Many K-12 teachers have not experienced science learning in this way and need opportunities to meaningfully make sense of scientific modeling, reflect on how this practice builds on or contrasts with their current science pedagogies, and establish a repertoire of strategies and tools for supporting scientific modeling in the classroom. Insufficient metamodeling knowledge—knowledge about the nature and purpose of scientific models (Schwarz & White, 2005)—impedes the ability to engage in the scientific practice of modeling. The first purpose of this study was to identify inservice teachers' metamodeling knowledge. Analysis revealed that inservice teachers viewed the nature and purpose of scientific models in one three distinct ways: a visual or physical representation, a sensemaking tool, or a pedagogical strategy. The second purpose was to examine whether PD designed using ambitious science instructional practices (Windschitl et al., 2012) would help inservice teachers situated in a particular local context develop metamodeling knowledge consistent with the new and more global vision of science education. Findings suggest that learner-based PD activities designed using the ambitious science teaching framework foster inservice teachers' metamodeling knowledge.

The Influence of Teacher's Perceptions of School Environment on Student Learning in Science

Rachel Shefner, Loyola University Chicago
Stacy Wenzel, Loyola University Chicago
Nayantara Abraham, Loyola University Chicago
Kelly Holmes, Loyola University Chicago

ABSTRACT:

Recent policy changes including Every Student Succeeds Act (ESSA) and the Next Generation Science Standards (NGSS) are changing the landscape for science teachers. It is therefore critically important to further refine the supports that teachers need in order to navigate these changes. Based on evaluations of a three-year professional development program in a large urban district, we use Desimone's conceptual framework model (2009) for studying professional development, and suggest refinements that parse out elements of teachers' internal and external environments in order to understand which of these elements are related to student learning. We have found that teachers' perceptions of fewer barriers to instruction in their school is a significant predictor of student engagement with inquiry-based science instruction, and that teachers' attitudes about NGSS are a marginally significant predictor of

student engagement with inquiry-based science instruction. This suggests that professional development that addresses these barriers to instruction may yield better outcomes for students of teachers in professional development programs.

Strand 8: In-service Science Teacher Education
NGSS
10:15am-11:45am, Hyatt Crockett AB
Presider: Tonya D. Jeffery, Texas A&M University

Effect of Long-term Supportive Professional Development on NGSS Implementation
Cindy L. Kern, Quinnipiac University
Amanda Bozack, Radford University
Rosemary Whelan, University of New Haven
ABSTRACT:
To date, 18 states and the District of Columbia have adopted the NGSS, presenting each state with the challenge of providing meaningful professional development to support science educators' enactment of the standards with efficacy and fidelity. However, educational reform requires more than an understanding of the standards and research-based teaching practices. Systemic support, in the form of school and district leadership, is imperative for teachers to confidently engage their students in the NGSS. Combined, institutional constraints and ineffective structures for professional development represent significant challenges to teachers' efforts and ability to implement the NGSS with fidelity. The study described the outcome of a professional development project designed to increase beginning teachers', mentors', and evaluating administrators' understanding and use of NGSS-based instructional practices.

NGSS and CCSS Integration in Secondary Classrooms: Implications from an Interdisciplinary Teacher Professional Development Program
Susan Gomez Zwiep, California State University, Long Beach
ABSTRACT:
This study took place within a three-year STEM PD program designed to develop teacher expertise in integrated Science, Math and English project-based learning units. Participants (n=75) were grades 6-8 math, science and English language arts teachers in an in a diverse suburban area (socio-economic and racial) school district. The study focused on two research questions:1) What areas of CCSS-Math, CCSS-ELA and NGSS do teachers select for integration in middle-school projects? and 2) What are teachers' perceptions about integrated STEM curriculum? The two primary PD components were a weeklong, summer institute and a school-year cross-curricular unit planning that included a lesson-study component. Descriptive statistics were used to identify trends in the integrated projects teachers designed and trends from year 1 and year 3 compared. The frequency of disciplinary ideas and practices used in each integrated unit were analyzed as were overall themes used to coordinate math, science and ELA classes. Qualitative methods were used to analyze teacher responses from PD evaluations, teacher reflections, interviews and program artifacts. The study provides insight into the feasibility of an integrated STEM-PBL model. The study concludes with implications for practice and a discussion of how future interdisciplinary professional development can be conceptualized.

Secondary Teachers' Struggles to Develop Coherent NGSS Instruction
William A. Sandoval, University of California, Los Angeles
Nathan Cournoyer, University of California, Los Angeles
Na'im Eggleston, University of California, Los Angeles
Anahid Modrek, University of California, Los Angeles
Jarod Kawasaki, University of California, Los Angeles
ABSTRACT:
We report on two dozen middle and high school science teachers' efforts to re-design their instruction around NGSS science and engineering practices during the course of one year of professional development (PD). Teachers worked in grade-alike subject teams to develop a common unit of instruction, observed their own teaching, and debriefed the experience. They conducted this cycle in both the fall and spring semesters of one school year. Our interpretation, as researchers, was that their initial efforts did not resemble desirable instruction, so we introduced a tool to promote teachers' thinking around unit coherence. Using this tool in their second cycle generated more coherent, and more student-centered, instruction compared to their first efforts. Our analysis of the challenges teachers face in adapting to NGSS suggest PD should attend to framing the purposes of science teaching and learning.

Teachers' Ideas about Teaching the Science Practices in the Next Generation Science Standards
Jarod Kawasaki, University of California, Los Angeles
William A. Sandoval, University of California, Los Angeles
Lilia Rodriguez, University of California, Los Angeles
ABSTRACT:
An important means to get at teachers' understanding of the new science practices in the NGSS is to examine the opportunities they provide to students to engage in them. Documenting the versions of science practices that teachers describe and promote in their classrooms provides insight into the instructional goals teachers have for their students and how they understand the goals of the

NGSS. Examining the tensions between teachers' goals and the goals in the NGSS highlight the learning issues needed to support teachers' enactment of the NGSS in the way it was envisioned. In this study, secondary science teachers were interviewed about their classroom instruction around the science practices in the NGSS to understand the different instructional goals teachers pursued and their relation to the goals of the NGSS. The tensions between teachers' goals and the goals of the NGSS call attention to some of the issues around teacher learning in the NGSS that emerged within this sample of teachers.

Strand 9: Reflective Practice
Reflective Practice - Paper Session B
10:15am-11:45am, HBG Convention Center 006A
Presider: Allan Feldman, University of South Florida

Argumentation and Modelling in a High School's Chemistry Class
Kira Padilla-Martinez, Facultad de Quimica, UNAM
José M. Montaño-Hilario, Facultad de Química, UNAM
ABSTRACT:
Scientific thinking skills are considered as a fundamental element for students to improve their comprehension of science concepts. Chief among them are argumentation and modeling, which are quite important to understand chemistry concepts. In this paper an action research is described, where for a period of one school term strategies for argumentation and modeling are taught in a high school's first course of chemistry. Toulmin's grid of argumentation was used to teach students to argue. To model it was necessary to explain to them that every time they made a representation at different levels (macroscopic, microscopic and symbolic), they were actually modeling. To assess students' activities, Mendoça and Justi's (2014) rubric was modified in such a way that now it is more general and can be used for any topic as long as it is used to assess arguments and models. Our results have shown that students' skills are improved if they are working with them continually. However, we think that it is necessary that students develop these skills in other courses because in spite of our effort they did not develop them to the highest level. 0 0 1 188 1039 Facultad de Química 8 2 1225 14.0 96 Normal 0 21 false false false ES-MX JA X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Tabla normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0cm 5.4pt 0cm 5.4pt; mso-para-margin:0cm; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:10.0pt; font-family:"Times New Roman";}

Building an Understanding: What Motivates Teachers to use a Science Outreach Project
Karen Spuck, Clarion University
ABSTRACT:
A science outreach project at a university in a rural location provides curricula, scientific tools, and professional development for economically disadvantaged schools. The project is free of charge, and participation is voluntary. What motivates teachers to use this resource? The purpose of this study was to discover what encourages volitional use of the outreach project. Through qualitative methods, it was found that these teachers possess exemplar teaching qualities including: inquiry teaching practices, inspiring students through motivational experiences and real world connections, engaging students to develop science literacy and a depth of understanding, and a devotion to life-long learning. Teachers also reported it was the project itself that encouraged use. The project was reported to be a user-friendly resource that helped them reach their teaching and learning goals. The teachers reported they felt a sense of community, ownership and empowerment as they were given an opportunity to have a voice as the project developed over the years. This study has implications for pre-service teacher programs, in-service teacher professional development, and outreach initiatives.

Developing Protocols to Support Collaborative Teacher Reflection and Professional Learning for Science Argument Writing
Naa Ammah-Tagoe, SRI International
Kyra Caspary, SRI International
Tanya Baker, National Writing Project
Eric Greenwald, Lawrence Hall of Science
Linda Friedrich, National Writing Project
ABSTRACT:
Through design-based research, a team of researchers collaborated with the National Writing Project to develop a series of three protocols to stimulate teachers' reflection on a lesson series designed to support students' science argument writing: a planning protocol for assignment and supporting lesson design; an assignment protocol to support collaborative reflection on a writing task and its instructional surrounds; and a consultancy protocol to help teachers guide a larger group examination of student work. The protocols are designed to be used by teachers–either individually or as part of a professional learning community–or by professional development providers to guide the development of an assignment, or to analyze the assignment and instructional supports.

Participatory Action Research Examining Use of Annotated Videos by Pre-Service Teachers to Promote Reflective Practice
Gloria J. Hardrict-Ewing, University of Missouri, St. Louis
ABSTRACT:

This study investigates the effect of annotated videos on the reflective practice of pre-service STEM teachers. Current research suggests teachers reflecting on their practice is "key to improving their instruction (van Es & Sherin, 2008, p. 246)." The present study engaged pre-service teachers in action research utilizing mixed methods, and spanned three semesters. The participants consisted of two cadres of pre-service teachers who planned collaborative STEM units. The participants used annotated videotaped instruction to reflect on their pedagogy, and to critique instruction of their colleagues. Reflecting on STEM instruction holds implications for improving pedagogy. U.S. News STEM Solutions (Morella, 2013) reported that 15-year-olds in the United States ranked 25th and 17th respectively in math and science compared to their peers worldwide, indicating students are lacking quality STEM education. Educators not comfortable with teaching STEM concepts may avoid or minimally teach them (Bursal & Paznokas, 2006 according to Nadelson). A need exists to improve teaching of STEM content. This study will examine the effects of reflective practice when pre-service teachers used annotated videos to critique STEM instruction. Annotated videos may provide a much needed platform for beginning teachers to improve their practice and affect student achievement.

Strand 10: Curriculum, Evaluation, and Assessment
Related Paper Set: The Long and Winding Road to NGSS Implementation
10:15am-11:45am, HBG Convention Center 006C
Discussant: Joseph Krajcik, Michigan State University
ABSTRACT:
The NRC (2012) Framework argues for organizing instruction and standards around three dimensions of science: science and engineering practices, disciplinary core ideas, and crosscutting concepts. Shifting from traditional science teaching to three-dimensional (3D) instruction will be difficult for teachers and students. Students struggle to link atomic-level structure and interactions with macroscopic scale observations of phenomena. We developed a curriculum intending to support students and teachers in 3D learning by focusing on students constructing and using models and writing explanations of electrostatic phenomena. We conducted research as eleven teachers implemented this curriculum in their high school science classes in a range of school contexts across the US. Our combined work focuses on supporting student learning of difficult physical science concepts through curriculum and instruction, and supporting teachers learning to provide equitable learning opportunities for students. Our studies show that 3D learning around a complex topic at times felt uncomfortable. However, in the end students made significant progress in their learning and science identity while teachers used supports provided to implement new equitable practices into their teaching and increased understanding of 3D teaching.

Does a Focus on Modeling and Explanation of Molecular Interactions Impact Student Learning and Identity?
Steven Mcgee, Northwestern University
Randi McGee-Tekula, The Learning Partnership
Jennifer Duck, The Learning Partnership

Developing and Empirically Validating Hypothetical Learning Progression For Three Dimensional Learning of Electrical Interactions.
Leonora Kaldaras, Michigan State University
Joseph S. Krajcik, Michigan State University

Students' Development and Use of Models of Atomic Structure
Kristin Mayer, Michigan State University
Joseph S. Krajcik, Michigan State University

Supporting Teachers in Developing Inclusive Three-dimensional Learning Environments During Class Discussions
Angela D. Kolonich, Michigan State University
Gail Richmond, Michigan State University
Joseph S. Krajcik, Michigan State University

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set: Exploring Artscience: Identity, Connection, and Agency with Science through Art
10:15am-11:45am, HBG Convention Center 008B
Discussant: Edna Tan, University of North Carolina At Greensboro
ABSTRACT:
Despite similarities between the practices of artists and scientists, much is yet to be learned about ways of connecting art and science practices pedagogically in the design of "artscience" (Root-Bernstein, 2004) learning environments. In particular, more empirical work needs to be done on how art-inspired science learning environments can realize learners' multiple intersecting identities and push on normative practices within science education that often do not leave room for explicit attention to the connection between science and other domains such as art. In this related paper set, we explore the ways in which artscience learning environments—

across multiple domains such as microbiology, robotics, evolutionary biology, and climate science, offer identity resources for learners to connect with science, art, and their families in new ways.

Colors of Nature: Art/Science Agency in Intersecting Figured Worlds
Blakely Tsurusaki, University of Washington
Carrie T. Tzou, University of Washington, Bothell
Laura Conner, University of Alaska Fairbanks
Mareca Guthrie, University of Alaska Fairbanks
Stephen Pompea, National Optical Astronomy Observatory

Artscience: Fostering Active Relational Involvements with Microbial Life
Ann S. Rosebery, TERC
Beth Warren, TERC
Déana A. Scipio, TERC
Tammie Visintainer, TERC

Tech Tales: Connecting Robotics with Family Storytelling
Carrie T. Tzou, University of Washington, Bothell
Megan Bang, University of Washington
Philip L. Bell, University of Washington
Theresa Hortsman, University of Washington, Bothell
Shelley Stromholt, University of Washington
Gabriel A. De Los Angeles, University of Washington
Nancy Price, University of Washington

Complex Systems, Story and Art: Engaging Native Youth in Learning About Climate Change
Megan Bang, University of Washington
Priya Pugh, University of Washington
Megan McGinty, University of Washington

Strand 12: Educational Technology
Understanding with Technology
10:15am-11:45am, Hyatt Travis CD
Presider: David B. Vallett, University of Nevada

Changes in Students Phylogenetic Tree-Reading: A Quasi-Experimental Design Study
Carrie J. Bucklin, Southern Utah University
Kristy L. Daniel, Texas State University
ABSTRACT:
Evolutionary relatedness, like many other phenomena in science, is a difficult topic to understand, let alone teach. This topic's difficulty is compounded by the complexity of phylogenetics and phylogentic trees (evolutionary trees). A person's ability to read and use phylogentic trees is influenced by their ability to use representations in general and their understanding of the scientific language used when describing these trees. There are a variety of projects or classroom activities available to help students learn to read and build phylogenetic trees, including technology-based representations. I conducted a mixed-methods study to investigate the changes in students' tree-reading and levels of tree-reading representational competence after varied forms of instruction: A) No Instruction, B) Lecture only, C) Virtual Lab only, and D) Lecture & Virtual Lab. Participants included students enrolled a two-course introductory biology series: Principles of Biological Science I and II (n=128). I found that repeated, explicit instruction, that incorporated multiple types of representations, resulted in a larger increase in mean scores on a tree-thinking assessment and a larger increase in level of tree-reading representational competence. My findings suggest that technology-based representations alone are not as beneficial to student learning as when they are used in conjunction with lectures.

Determining the Effects of Computer Assisted Predict-Observe-Explain Technique in General Biology Courses
Yilmaz Kara, Karadeniz Technical University
ABSTRACT:
This study was conducted to investigate the effects of computer assisted predict-observe-explain technique for the instruction of general biology. A pretest–posttest control group included quasi experimental design was adopted. The participants of the experimental group were taught through the computer-assisted instruction, whereas the comparison group students received constructivist instruction. The t-test was applied to the data obtained through the instruments of the study. Consequently, the computer assisted predict-observe-explain technique was more effective than the constructivist activities in order to fulfill the cognitive objective requirements. But both constructivist and computer assisted activities could not able to make statistically meaningful change

for the behavioral objectives within the limited time period of study. Keywords: Science Education; Computer Assisted Instruction: Curriculum and Instruction.

Evaluating Role of Interactive Visualization Tool in Improving Students' Conceptual Understanding of Chemical Equilibrium
Bharath Kumar, Unveristy of Kentucky
Rebecca McNall Krall, University of Kentucky
ABSTRACT:
The purpose of this study was to examine the role of simulation towards student's concrete conceptual understanding of chemical equilibrium. Students find chemistry concepts abstract, especially at the microscopic level. Chemical equilibrium is one such topic. Kress et al (2001) suggested that external representation in the form of visualization is more than a tool for learning, because it enables learners to make meanings or express their ideas which cannot be readily done so through a verbal representation alone. A quasi experimental mixed method study design was employed in the study. ANCOVA analysis was conducted on the quantitative data. This test was found to be statistically significant, $t(23.84) = 8.619$, $p < .001$; $d = 3.33$. The effect size for this analysis ($d = 3.33$) was found to exceed Cohen's (1988) convention for a large effect. These results indicate that participants in the experimental group ($M = 7.27$, $SD = 1.387$) received higher scores on the CEMT post intervention than did participants in the control group ($M = 2.67$, $SD = 1.371$). KR-20 analysis was conducted on the dichotomous data and the Cronbach's alphas was found to be 0.71. Conditional probability analysis was performed to establish construct validity.

Student Understanding about Exponential Growth and the Richter Scale following an Embodied Digital Simulation
Jason Morphew, University of Illinois
Nitasha Mathayas, University of Illinois, Urbana Champaign
Sahar K. Alameh, University of Illinois, Urbana Champaign
Robb Lindgren, University of Illinois, Urbana Champaign
ABSTRACT:
Reasoning about both linear and non-linear changes, as well as differentiating when each type of reasoning in required, is essential for developing scientific understanding in many content areas. The need to connect these understandings, which are typically taught in math courses, is highlighted in the crosscutting concepts of the Next Generation Science Standards. While many opportunities for making connections between content areas are noted in the NGSS, there is little consensus on how to facilitate these connections. From a constructivist perspective, student conceptions emerge dynamically from existing conceptions. Research in embodied cognition asserts that student conceptions are grounded in experience. This study investigates student reasoning about exponential growth within science contexts before and after participating in an embodied math simulation which "cues" students to use gestures aligned with conceptual understanding to operate the simulation. Twenty-four high school students participated in task-based interviews which included a pre and post-assessments which asked about doubling and the Richter scale. The results show that many students were able to provide more sophisticated explanations of exponential growth after interacting with the simulation. However students' predictions suggest that students might benefit from additional instruction paired with the embodied simulation for some concepts.

Strand 12: Educational Technology
Designing for Learning
10:15am-11:45am, HBG Convention Center 006B
Presider: Joshua A. Ellis, Michigan Technological University

SEM or STEM? Variations in Science Teachers' Technology Integration in a Co-designed STEM Unit
Angelina Constantine, University of Minnesota
Paula S. Rozowa, University of Minnesota
Alaina Szostkowski, University of Minnesota
Joshua A. Ellis, Michigan Technological University
Gillian Roehrig, University of Minnesota
ABSTRACT:
In the age of STEM education, teachers consistently struggle to understand the nature of technology and how to integrate it. This multiple-case study uses the TPACK framework to explore the beliefs and enactment of three elementary science teachers from an urban school district with a recently implemented 1:1 iPad policy. All three teachers participated in a professional development opportunity in which they co-developed and implemented a STEM curriculum unit in collaboration with a graduate student coach; however, they did not receive explicit support on how to integrate technology with their teaching. As a result, the authors were later able to explore these science teachers' existing beliefs and enactment regarding technology. Data sources for the study included interviews, coaching sessions, and classroom observations. Qualitative analysis revealed three distinct applications of TPACK. Interestingly, one teacher with a prior stated interest in iPad technology sustained his commitment throughout the unit, but two other teachers who displayed more ambivalence regarding iPad effectiveness either limited or discontinued their use of the device during implementation. Findings explore how teacher beliefs regarding technology and iPads (whether as a "purposeful tool for differentiation" or a potential "distraction" potentially limited by technical difficulties) influence their practices.

Evidence-centered Design & Usability Analysis: An Iterative Design Approach to a Genetics Digital Learning Environment
Eric N. Wiebe, North Carolina State University
James H. Creager, North Carolina State University
Osman Aksit, North Carolina State University
Katherine Chesnutt, North Carolina State University
Bita Akram, North Carolina State University
Bradford Mott, North Carolina State University
James C. Lester, North Carolina State University
Frieda Reichsman, The Concord Consortium
Chad Dorsey, The Concord Consortium
ABSTRACT:
This study reports on the combined strategy of using the evidence-centered design (ECD) framework and usability heuristics to synthesize the learning goals of an existing science learning software platform; utilizing affordances provided by the current software for both forwarding learning and providing behavioral trace evidence of students meeting learning goals. The Conceptual Assessment Framework layer of ECD was used as a diagnostic tool in conjunction with usability heuristics to guide design of the next generation of the learning platform. Three in-depth examples of design refinements, including user interface changes and the development of new data streams for adaptive support systems, are presented. Lessons learned provide a systematic process for building an evidence database of student conceptual understanding while also improving a system's ability to support and reveal student conceptual growth. This study illustrates how ECD provides a common language for people from different disciplines, such as curriculum design, software development, and research, to communicate with each other.

Geospatial Technology as Show-and-tell or Game-changer? Science Teachers' TPACK Development in a PD Course
Bridget K. Mulvey, Kent State University
ABSTRACT:
Despite the essential role spatial thinking plays in student success in STEM, K-12 teachers are largely unprepared to incorporate spatial thinking and supportive geospatial technology into their science instruction. The present investigation explored 15 secondary science teachers' developing geospatial technology, pedagogy, and content knowledge (TPACK) in the context of an inquiry-based earth system science professional development program (PDP), informed by a flexibly adaptive approach. Data sources per participant included lesson artifacts, video-recorded and/or in-person observations, and written reflections. Results indicated that all participants improved their geospatial TPACK. All participants taught by inquiry, integrating images (satellite, aerial), maps, and/or spatial data into their instruction more than the previous year. All but one participant implemented technology-enhanced inquiry instruction. Three themes of change characterized participant TPACK growth: increased attention to spatial nature of science inquiry; shift from geospatial technology like Google Earth as visualization tool to science inquiry tool; increased student responsibility and differentiation to meet students' needs. The development of a community of practice, supported by a flexibly adaptive PDP approach, was particularly important to the effectiveness of the PDP.

Concurrent Session #5
1:15pm – 2:45pm

Equity and Ethics Committee Sponsored Session
Admin Symposium: Poster Symposium - Jhumki Basu Scholar Symposium: Equity and Excellence in Science Education
1:15pm-2:45pm, Hyatt Presidio ABC
Presiders:
Nam-Hwa Kang, Korea National University of Education
Sanghee Choi, University of North Georgia
S. Lizette Ramos-de Robles, Universidad de Guadalajara
ABSTRACT:
The Equity and Ethics Committee invites you to join this exciting and compelling interactive poster session with the 2016 Basu Scholar awardees. The fourteen eminent scholars represent a spectrum of various career stages and research interests in scholarship involving equity and excellence in science education. The scholars share their ideas and research that span a broad range of science education, including diversity and social justice in learning and teaching science. The scholars bring diverse educational perspectives that will shape science education, and they present new approaches to help us understand challenges and successes of science teachers, students, and programs.

A Case of Design Based Online Teacher Professional Development to Introduce Integration of STEM
Tasneem Anwar, University of Minnesota

How Science Teacher Educators of Color Conceptualize and Operationalize their Pedagogy in Science Methods Courses

Sumreen Asim, University of North Texas

The Perspectives and Experiences of African American Students in an Informal Science Program
Dominique Bulls, University of North Carolina at Chapel Hill

Elephant in the Classroom: Social Positioning of Emergent Bilingual Students and Implications on Science Identity Development
Shakhnoza Kayumova, University of Massachusetts Dartmouth

In the Midst of a Disaster: A Critical Analysis of Relationships between Science Curriculum Development, Implementation, and Local Environmental Injustice Crises
Corey Knox, University of Arizona

The Impact of Place-based Case Studies on Student Learning and Affect in Introductory Biology
Lynnsay Marsan, University of Texas at El Paso

Gendered Performance Differences in Introductory STEM Courses are Consistent across Five Universities
Rebecca Matz, Michigan State University

STEM Story-Telling Online Resource for Inclusive EnvironmentS (STEM STORIES)
Ayana McCoy, University of Massachusetts Boston

Science Teacher Identity Development through a Black Feminist Lens: Stories of Resilience, Resistance, and Struggle for Recognition
Olayinka Mohorn, University of Illinois at Chicago

Examining the Influence of Physics Focused Professional Development on Advanced Placement Teachers - A Case Study
Justina Ogodo, University of Alabama

The Use of a Sociocultural Construct to Examine four Hispanic High School Students' Experiences in a Lunar Research Program
Catherine Quinlan, Howard University

Pre-Service Science Teachers in Culturally Diverse Classrooms
Suzanna Roman, Georgia State University

Middle School Teachers' Experiences with Engineering Design Projects: Supporting English Language Learners and At-Risk Students in STEM
Diane Silva Pimentel, University of New Hampshire

Designing Equitable Science Learning Environments for Elementary-aged Emerging Bilingual Students
Enrique Suarez, University of Colorado Boulder

Research Committee Sponsored Session
Admin Symposium: Methodological, Ethical, and Identity Issues in Naming Ourselves and Others
1:15pm-2:45pm, Hyatt Seguin AB
Presenters:
Maria S. Rivera Maulucci, Barnard College
Felicia Moore Mensah, Columbia University
Carolyn A. Parker, The John Hopkins University
Renee S. Schwartz, Georgia State University
Phillip A. Boda, Columbia University
Fouad Abd-El-Khalick, University of North Carolina, Chapel Hill
Dana L. Zeidler, University of South Florida
ABSTRACT:
Among the many concerns of researchers is how we represent ourselves and the individuals or populations who participate in our research projects. In an increasingly global community, the norms for the design, conduct, and reporting of research must transcend the local and be able to speak to a world audience with respect. A review of the literature reveals at least three methodological concerns for the design and conduct of educational research: 1) research design issues related to the use of racial and ethnic categories 2) ethical issues related to confidentiality, anonymity and use of unbiased language; and 3) issues of identity and intersectionality. First, the use of race as a descriptor of populations and as an independent variable in research has come under severe critique and researchers must ensure that their use of racial, ethnic, and other categories are appropriate for their study. Second, researchers must be careful to use unbiased language as they describe the participants involved in their research. The American Psychological

Association (APA) provides guidelines for reducing bias in research reports. However, the APA recommendations are not without their critiques and they constitute a moving target; thus, researchers must remain vigilant regarding changes in naming practices. Furthermore, requirements regarding confidentiality and anonymity may conflict with participants' desires for full disclosure or proper masking of research participants or sites. Finally, issues of identity and intersectionality require researchers to consider how the pseudonyms and labels used to describe individuals, groups, places, or settings might excavate, accentuate, hide, or silence aspects of identity that may be salient to the research study or contribute to deficit notions or stereotypes. This session will provide a venue to explore and discuss each of these issues and to develop guidelines for NARST members to use in the design, conduct, and reporting of their research.

Strand 1: Science Learning, Understanding and Conceptual Change
Understanding the Science of Earth and Space
1:15pm-2:45pm, HBG Convention Center 006D
Presider: Muhsin Menekse, Purdue University

Development of a Learning Progression about Stars and their Properties
Silvia Galano, University of Camerino, Italy
Arturo Colantonio, Liceo Statale, Italy
Silvio Leccia, INAF, Capodimonte Astronomical Observatory of Naples, Italy
Emanuella Puddu, INAF, Capodimonte Astronomical Observatory of Naples, Italy
Italo Testa, University of Naples, Italy
ABSTRACT:
In this paper, we discuss the iterative development of a learning progression about "Stars", a cross-cutting concept that connect different content areas as mechanics, thermodynamics, quantum mechanics, and chemistry. Analysis of 33 interviews with secondary students informed a hypothetical learning progression based on three dimensions that form the concept of Stars: 1) mechanical equilibrium, 2) composition and aggregation state, 3) functioning and evolution. To assess the validity of the hypothesized learning progression, we then accordingly designed a twelve-hour teaching intervention, which featured paper-and-pencil tasks, practical activities to estimate stars' parameters, and planetarium observations. Twenty secondary students were then interviewed before and after the teaching intervention and collected data were used to revise the initial learning progression and the teaching intervention. The revised version of the learning progression was then assessed with 30 secondary school students. A final version of the learning progression was then developed drawing on students' emerging reasoning trategies. Overall, our findings provide insights into difficulties students experience in explaining stars and about related topics and might inform suitable instructional activities.

Students Learning about Science Practices in Astronomy: The Role of Telescopes in Astronomical Investigations
Timothy G. Gleason, Pennsylvania State University
Julia Plummer, Pennsylvania State University
Chrysta Ghent, Pennsylvania State University
Christopher Palma, Pennslyvania State University
ABSTRACT:
This study describes student ideas about how astronomers plan and carry out investigations, with an emphasis on telescopes and related instrumentation. Students in a middle school classroom participated in a 15-week curriculum, designed around the practices of astronomy. Three lessons focused on telescope use and related instrumentation. Students were interviewed before and after instruction about how astronomers study objects in our Solar System and beyond. Analysis of student interviews (N=12) showed significant improvement on how they described astronomers' use of telescopes, cameras, and spectroscopy to investigate nearby objects, complex problems requiring observation over time, and measuring distant objects' composition. Their responses were limited in the complexity, such as how they combined instruments with telescopes or discussed how these observations could be used as evidence for a claim. Engaging students with telescopes, cameras, and spectroscopy may have contributed to their understanding of how astronomers use these instruments to gather data during investigations. However, students needed more specific experiences on how these are used to collect data, such as how spectroscopes are connected to telescopes. Still, students' progress in this study shows promise for how instruction can support their understanding of discipline-specific practices in astronomy.

Identifying Early Productive Stepping Stone Conceptions of Three-dimensional Earth Science Understanding by High School Students
Anna Beck, Columbia University
Allison Bookbinder, Columbia University
Min Jung Lee, Columbia University
Ann E. Rivet, Columbia University
ABSTRACT:
Learning progressions characterize the development of students' science understanding from an initial naive idea (lower anchor) to more sophisticated conception (upper anchor). The development of this understanding is described in terms of stepping stone ideas that are incomplete or inaccurate yet productive to reaching the end goal understanding. We coded 35 student responses to an assessment task focused on students' explanations of the breakup of Pangea related to plate tectonics from the perspective of three

different crosscutting concepts. Through iterative coding, we identified and described three trends in students unsuccessful explanations of this phenomena: inability to apply crosscutting concepts accurately, the use of scientific vocabulary without meaning, and the substitution of description for explanation. We believe that these different ways in which students erroneously explained the phenomena can still be viewed as productive steps towards their efforts to develop sophisticated three-dimensional understandings of science.

The Role of Perspective Taking in How Middle School Students Explain Lunar Phases
Abha M. Vaishampayan, Pennsylvania State University
Julia Plummer, Pennsylvania State University
Kyungjin Cho, Pennsylvania State University
Patricia Udomprasert, Harvard University
Erin Johnson, Harvard University
Susan Sunbary, Smithsonian Astrophysical Observatory
Henry Houghton, Harvard University
Erika Wright, Smithsonian Astrophysical Observatory
Helen Zhang, Boston College
Alyssa Goodman, Harvard University
ABSTRACT:
This study investigates middle school students' spatial thinking, especially their use of perspective taking (PT), in understanding lunar phases. For this purpose, we interviewed 11-12 years old students (N=20) before and after a three-day instruction lab about lunar phases. The lab curriculum comprised of using physical and virtual models of Sun, Moon and Earth to engage students in visualizing spatial systems. Students' interviews were coded based on their reasoning and the way they used gestures and verbal communication to make connections between different perspective. Our findings show that students with high PT skill tend to make accurate connections between the Earth and space-based perspectives to explain lunar phases. We also found that there was a significant overall improvement in how students connect multiple perspectives after the spatial thinking curriculum. A qualitative analysis of the normative and non-normative responses shows that development of systems spatial thinking requires a combination of spatial skills and content knowledge. This research can be helpful in understanding the role of spatial thinking across other phenomena in astronomy that require spatial transformations. The methods used for the study can be useful in exploring relationship between spatial skill and development of expertise in other STEM domains.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Examining Teacher Roles
1:15pm-2:45pm, HBG Convention Center 007A
Presider: Ryan Summers, University of North Dakota

Exploring Teachers' Framing of Citizen Science
Emily Harris, University of California, Davis
Heidi Ballard, University of California Davis
ABSTRACT:
This study explored how teachers frame classroom citizen science work, making clear to students what they are doing and why, when students collaborate with scientists to produce new scientific knowledge. Specifically, the study investigated the relationship between how teachers position students as epistemic agents in building new scientific knowledge (epistemological framing) and how teachers situate students' work beyond the classroom as part of broader conversations that extend across time, places, and people (expansive framing). Drawing from videos of classroom teaching and teacher interviews, this paper analyzes the interactions between these multiple framings as well as what contributed to teachers' framing choices. Findings indicated three main relationships: teachers' epistemological and expansive framings can oppose one another, reinforce one another, or have no interaction. These relationships were attributed to teacher's goals for their citizen science lessons, beliefs about science and science teaching, and level of preparedness for the lessons. This work has implications for how to achieve dual science education goals for students' participation in scientific practice and ability to transfer science learning from the classroom into their daily lives.

Testing the Impact of Situational Features on Measures of Biology Students' Genetics Understanding
Robyn Tornabene, Stony Brook University
Ross H. Nehm, Stony Brook University
Philipp Schmiemann, University of Duisburg, Essen
ABSTRACT:
A substantial literature in cognitive psychology has produced strong evidence that assessment task features--the framing, context, or situation in which problems are posed--can impact the retrieval of knowledge and resulting measures of understanding. The overarching goal of our study was to explore the potential role that situational features play in the measurement of students' understandings of Mendelian genetics. 77 items differing in situational features were administered to 444 undergraduate students using a multi-matrix test packet design. Rasch analysis of scores produced good item fit. ANOVA and Pearson correlation tests found

no significant differences in performance between genders (F(1,416)=0.009, p=0.926) or between ethnic groups (F(5,412)=0.412, p=0.834). There were no significant correlations between students' performances and ages (r=-0.02, p=0.747) or the number of biology courses taken (r=-0.030. p=0.533). Surprisingly, we found no significant differences among animal, plant, and human item contexts (H(2)=0.805, p=0.668) or between fictitious and real item contexts (U=624, p=0.398). Our findings are an important first step for better understanding which situational features play significant roles in the measurement of students' genetics reasoning.

The Impact of Questioning Techniques on STEAM Instruction
Heidi Cian, Clemson University
Lorraine A. Jacques, Clemson University
Cassie Quigley, Clemson University
Danielle Herro, Clemson University
ABSTRACT:
The purpose of STEAM education is to engage students in authentic problem-based learning challenges challenges that transcend the disciplines and emphasize 21st century skills such as collaboration and communication (Guyotte et al., 2015; Yakman, 2010). Though interest exists in using STEAM, little research is available on how to successfully implement the practice. However, research does suggest that in order to engage students in meaningful thinking about realistic problems, diversified questioning techniques are needed as part of the instructional practice (Chin, 2007; Webb et al., 2008). This study used observational data from middle-grades teachers engaged in STEAM practices to learn what questioning techniques support or impede STEAM instruction. Our findings show that questioning techniques that challenge student thinking or relate content to student experiences were demonstrated in classes with authentic STEAM instruction, while basic questioning techniques and questions that focus on task-specific behavior were demonstrated in classes that struggled with STEAM practices.

Variation in How Teachers Support Student Critique in Argumentation Discussions
María González-Howard, Boston College
Katherine L. McNeill, Boston College
ABSTRACT:
Students have traditionally held passive roles in science classrooms, interacting mainly with the teacher who disseminates uncontested facts. Yet, recent standards contend teachers should support students in constructing their own understandings of nature through engagement in science practices, such as argumentation. Partaking in argumentation requires that students work with peers, taking on new roles in the classroom. As such, in this study we examined how different classrooms engaged in argumentation discussions. Specifically, we focused on the ways teachers did and did not support student critique, an area in need of particular attention in the literature on argumentation. We employed a mixed methods approach, using social network analysis (SNA) and discourse analysis (DA), to examine argumentation discussions. The SNA helped us visualize interactional patterns between students in terms of critique, while the DA allowed us to explore the language teachers used to support student critique. Our findings offer insight into variation in patterns of student critique, as well as the different ways that teachers articulate the goal and expectation for students to evaluate peer's ideas. These results have implications for future research examining student critique in argumentation, particularly around the identification of instructional strategies that support this type of interaction.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Examining Novice Teachers in Elementary Classrooms
1:15pm-2:45pm, Hyatt Crockett CD
Presider: Anna Maria Arias, Illinois State University

Graduate Students' Knowledge and Beliefs of Teaching and Learning STEM by Integrating STEM through Agriculture, Food and Natural Resources (AFNR)
Hui-Hui Wang, Purdue University
Neil A. Knobloch, Purdue University
ABSTRACT:
Recruiting undergraduate and science technology, engineering and mathematics (STEM) career professionals and training them become qualified future STEM educators is a strategy to address STEM teacher shortage. The study explores 4 graduate students' knowledge and beliefs of teaching integrated STEM education through Agriculture, Food and Natural Resources (AFNR) to 5th grade students in after school programs. The findings suggest graduate students, who have career interests in teaching, have different viewpoints than school teachers and curriculum in terms of designing and teaching integrated STEM education.

Utilizing an Instructional Log to Examine Novice Teachers' Science Instruction: Profiles of Practice
Elizabeth Greive, North Carolina State University
James Minogue, North Carolina State University
Sarah J. Carrier, North Carolina State University
Temple A. Walkowiak, North Carolina State University
ABSTRACT:

Latent Profile Analysis (LPA) is a powerful methodology for disentangling the complexity of classroom practice and identifying patterns of instruction (or profiles of practice) for groupings of teachers (Halpin & Kieffer, 2015). In this study, we use instructional data collected using the Instructional Practices Log in Science (IPL-S) in conjunction with LPA to detect and decipher profiles of novice elementary-level teachers' science instruction. We do this in a practical way in hopes that others will see the utility of this analytical technique in their own work.

Voices from the Field: Constraints Encountered by Early Career Elementary Science Teachers
Teri N. Johnson, Virginia Commonwealth University
Katherine P. Dabney, Virginia Commonwealth University
ABSTRACT:
The purpose of this qualitative study was to examine the constraints encountered by early career elementary school teachers as they try to deliver high quality science instruction. Eleven pre-service and beginning teachers were interviewed about their experiences during the transition from graduate student to classroom teacher in elementary science education. During the analysis three categories of constraints related to high quality science instruction emerged: time for teaching science, prioritizing science instruction, and access to materials and resources. This study adds to the literature concerning constraints to teaching elementary science and demonstrates that factors beyond teacher preparation and teacher self-efficacy may negatively effect science instruction in elementary classrooms.

Effects of Female Role Models-driven Inquiry on Students' Images of Scientists and Scientific Career Awareness
Hsiang-Ting Chen, National SunYat-sen University
Hsin-Hui Wang, National SunYat-sen University
Ying-Yan Lu, National SunYat-sen University
Huann-Shyang Lin, National Sun Yat-sen University
Zuway-R Hong, National Sun Yat-sen University
ABSTRACT:
This study explored the effects of a female role models-driven inquiry on children's images of scientists and awareness towards scientific career. Thirty-two 4th graders were randomly selected to join a 10-week intervention and formed the experimental group (EG), which was provided inquiry-based science activities and demonstrated female scientist role models. Another 30 4th graders were randomly recruited as the comparison group (CG). All participants completed questionnaires to measure their images on scientists and scientific career awareness. Six target children from the EG with either the highest or the lowest scores on the pretest were observed weekly and interviewed following the posttest. Exploratory Factor Analyses and internal consistency were evaluated for reliability and validity of instruments; analyses of covariance and content theme analyses were examined the differences between the two groups. We found that EG children's total scores on scientific career awareness and on the interest in science, positive outcome expectation and career choice goal dimensions significantly outperformed the CG children. Additionally, EG children's stereotypical images towards scientists were significantly lower than the CG children. Interview and observation results were consistent with the quantitative findings. Key Words: Female role models-driven inquiry; images of scientists; scientific career awareness; elementary school student; Taiwan

Strand 5: College Science Teaching and Learning (Grades 13-20)
Student Beliefs and Identity
1:15pm-2:45pm, HBG Convention Center 007C
Presider: Zahra Hazari, Florida International University

Black Females in STEM Undergraduate Research Programs: Strengths and Assets Associated with Their Identity
Terrell R. Morton, University of North Carolina, Chapel Hill
Eileen Carlton Parsons, University of North Carolina, Chapel Hill
Caesar R. Jackson, North Carolina Central University
ABSTRACT:
This proposal provides initial insights from a study investigating the perceptions and experiences of Black students participating in a structured undergraduate research program. Using interviews, journal prompts, and observation data, we find that Black females participating in the undergraduate research program are not only conscious and aware of their racial and gender identity but find value and encouragement in them. The value associated with identity aids in their overall success and experience in STEM as well as the development of a STEM identity within the undergraduate research context. Resiliency, philanthropy, and determination are orientations these participants express as a result of a negative STEM encounter. These orientations serve as strengths and assets for their continued engagement in STEM, and the foundation of their STEM identity development. These findings provide a different perspective from what is currently present in the literature regarding the roles of demographic, social, and cognitive variables, as well as the undergraduate research experience, in Black student retention and matriculation in STEM.

Exploring Under-represented College Freshmen's Readiness for STEM Learning
Shiyu Liu, Ocean University of China
ABSTRACT:

The primary goal of the present study was to explore under-represented college freshmen's readiness for STEM learning. In particular, we focused on the nature of students' STEM self-efficacy, epistemic beliefs, and metacognitive skills to examine their affective, cognitive, and metacognitive readiness. Thirty-nine college freshmen who were ethnic minorities participated in this mixed-methods study. As quantitative findings revealed close relationships between students' self-efficacy, epistemic beliefs, and metacognitive skills in STEM, results from qualitative analysis showed that they held relatively low self-efficacy in STEM learning. Factors such as STEM curricula in high school and teachers' pedagogical approaches were among main contributors to under-represented students' perceived readiness for STEM learning in college. As our first steps in supporting students to enter the STEM pipeline, this work not only added to our understanding of student characteristics related to STEM learning, but also provided important implications for future efforts in bridging K-12 and postsecondary STEM education.

NOS Views and Epistemological Views of College Biology Students
Lisa A. Borgerding, Kent State University
Hasan Deniz, University of Nevada
ABSTRACT:
Epistemological views characterize how individuals view the certainty, source, and organization of knowledge. Previous research has demonstrated some relationships between epistemological views and NOS views. These relationships may be particularly interesting for biology students who are learning about topics such as evolution which are societally-controversial but not scientifically-controversial. In this study, we examine the relationship between epistemological views and NOS views for three classes of college biology learners using the LCQ survey to characterize participants' epistemological Perry Levels and part of the VNOS-C to characterize their NOS views. Based on a series of Chi Square analyses, no relationship between Perry Level and NOS views was identified. Significant relationships between Perry Level and year in school, NOS views and gender, and NOS views and biology class were identified. These findings and implications for future work are discussed.

The Effect of SAT Math scores on women's Self-Efficacy and its implications for Chemistry Learning
Paulette Vincent-Ruz, Learning Research and Development Center
Christian D. Schunn, University of Pittsburgh
ABSTRACT:
Women sometimes move away from science careers because of underperforming in science classes. Underachievement in science is often associated with a lack of skills, but can also be the product of a lack of science self-efficacy. Related research in mathematics has shown that even when girls have the same mathematical skills as boys, they self-report lower self-efficacy beliefs on their math abilities (OECD, 2015). This study explores whether math performance can impact science self-efficacy, specifically chemistry. Drawing from a dataset of over 1,800 students in a university in the eastern United States, we explored potential mediation relationships between gender, general math ability (SAT Math scores), self-efficacy in chemistry at beginning of the semester, and success in General Chemistry 1. Both prior math performance and chemistry self-efficacy predicted students' chemistry grades. We found that gender has both a direct effect on chemistry self-efficacy, and an indirect effect mediated by SAT math performance while controlling for SES, and other demographic variables. This mediation by math performance is surprising given that math performance is affecting self-efficacy in a different domain. Implications for high school and college instruction are discussed.

Strand 6: Science Learning in Informal Contexts
Lessons Learned from Maker Spaces and Afterschool Clubs
1:15pm-2:45pm, HBG Convention Center 007B
Presider: Aaron Price, Museum of Science and Industry, Chicago

Exploring Career Interests, Perceptions, and Content Knowledge of Rural, Underrepresented Middle School STEM Club Members
Margaret R. Blanchard, North Carolina State University
Kristie S. Gutierrez, North Carolina State University
Kylie J. Hoyle, North Carolina State University
Lauren A. Harper, Leesville High School
Jason L. Painter, North Carolina State University
N. Scott Ragan, North Carolina State University
ABSTRACT:
This mixed methods study explored the experiences of rural middle school students in 4 high poverty schools who took part in up to 19 after-school STEM Career Club meetings over 18 months. Participants (172) took surveys about their STEM interests, career intentions, and STEM Club perceptions, and completed content questions based on the Club's learning focus toward the end of each Club meeting. A subset of 101 students were interviewed with questions and analyses guided by the expectancy-value theory of achievement motivation. Students who attended meetings regularly (>10 meetings) demonstrated higher initial career interest scores and better content knowledge than students who attended sporadically. Students' subjective task value (i.e., enjoyment, utility, cost, interest), identity, and key socializers were motivational factors most often expressed as influencing students' learning and STEM intentions. The STEM Club perceptions survey indicated that students had positive club experiences, believed it was important, and perceived the Club staff as caring and knowledgeable. Students' perceptions of STEM subjects and potential careers were strongly

positive. Using multiple data sources, the motivations of this student population and their conceptual learning were gauged, and their interview narratives helped to operationalize these motivations.

Factors Related to Intended Climate Change Behaviors of Rural Middle School Students and Their Families
Kristie S. Gutierrez, North Carolina State University
Margaret R. Blanchard, North Carolina State University
ABSTRACT:
Attitudes about the environment are formed early in life and can be difficult to change. Therefore, interventions targeting beliefs about sociocultural issues should occur with students in upper elementary or middle school. This study examined factors related to the intended climate change behaviors of rural, middle school students and their families in the southeastern United States. Students in an after-school STEM club, with three meetings focused on climate change, were recruited to do an additional at-home intervention with their parents. Participants viewed and discussed questions before, during, and after video documentaries. Using the Determinants of Behavior model of climate change, audio data from the home intervention and interviews was coded to examine trends in climate change beliefs and content knowledge. Participants most often talked about climate change facts (knowledge), followed by behaviors, and the seriousness of the problem. Seventy-two percent of the participants held individualistic egalitarian worldviews. Families who had high engagement with the at-home intervention materials had the greatest changes in climate change content knowledge. Findings indicate that parents and students can markedly build content knowledge and positive attitudes from engaging in short-term climate change interventions in their own homes.

Improving Computational Thinking Skills and Physics Engineering Learning by Using Makerspace Activities and Formative Assessments
Yue Yin, College of Education University of Illinois, Chicago
Roxana Hadad, Northeastern Illinois University
Xiaodan Tang, University of Illinois, Chicago
Qiao Lin, University of Illinois, Chicago
C. Meghan Hausman, Northeastern Illinois University
ABSTRACT:
Although computational thinking (CT) has been believed to be a critical learning objective and a crucial factor to facilitate other STEM learning, researchers are still exploring effective ways to improve and assess CT. Our study is one of such efforts. Funded by the National Science Foundation, our project developed maker activities and formative assessments that promote physics and engineering learning as well as CT skills, which can be used in informal and formal educational settings. Our paper has two major goals: (a) Introducing our project activities, CT related maker activities, and instruments and (b) examining the impacts of the project on different project participants, including the leadership team, development team, informal educators, and students. The preliminary results showed, by participating in our maker activities, students improved significantly on the following measures: achievement test measuring physics and engineering knowledge and CT skills, interest in physics and engineering, CT dispositions, and frequency of using CT. Our study developed maker activities to improve CT skills and instruments to measure CT skills and dispositions. We bridged informal and formal science education by using maker activities to enhance CT skill improvement with physics and engineering learning.

Visual Literacies and Expansive Educational Opportunities: Using Images to Learn in Makerspaces
Eli Tucker-Raymond, TERC
Brian Gravel, Tufts University
Aditi Wagh, Tufts University
Briana Jefferson, TERC
Ada Ren, TERC
ABSTRACT:
This paper presentation explores the use of images as youth and adults in makerspaces create objects and in doing so, learn about what they are doing. Images serve three major purposes for people in the makerspaces we have studied: a) as a way to search for and identify information on the Internet, b) as a way to think through a particular problem that has arisen in object creation, and c) as a way to share work with others. We argue that attention to the use of images as a literacy practice in these three ways can help learning facilitators create and support expansive learning opportunities for makerspace participants.

Youth Engagement as Scientists and Engineers within a Making-related After-school Program
Amber Simpson, Indiana University
Adam V. Maltese, Indiana University
Alexandra M. Burris, Indiana University
ABSTRACT:
The aim of this study is to establish a foundation to inform and support the expected expansion of making programs by examining how youth are engaged in science and engineering practices within an informal learning environment. Utilizing the eight NGSS science and engineering practice standards as our initial coding scheme, we analyzed 22 GoPro videos of youth in grades 3-6 engaged in a variety of making activities. As indicated in our results, enactment of the NGSS practices "look" different. For example, in a

classroom, constructing an explanation is often completed on an exam or lab report, which makes the process easy to visualize for those wanting to assess this standard. Yet within our data, constructing an explanation most often occurred in conversation between children and their peers or teachers or simply in the process of iterative design itself. In addition, our findings support the notion that there is more to doing science and engineering than listed within the parameters of the eight NGSS practice standards. For example, we observed instances in which failures within students' design and exploration led to "informed" changes and continuation of play. In this presentation, evidence of our findings will be supported through video clips.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers and the Next Generation Science Standards
1:15pm-2:45pm, HBG Convention Center 006A
Presider: Stephen B. Witzig, University of Massachusetts Dartmouth

Elementary Preservice Teachers' Lesson Reflections on Promoting Norms of Interaction for Students' Engineering Design
Elaine M. Silva Mangiante, Salve Regina University
Adam Moore, University of Rhode Island
ABSTRACT:
The framework underlying the Next Generation Science Standards positions engineering design as an integral part of science learning in grades K-12 with the intent that students come to see themselves as members of a community who interact to propose, test, and critically evaluate potential design solutions to a problem while respecting each others' contributions (NRC, 2012). Yet, for productive discourse that supports collaborative problem-solving, students need to be exposed explicitly to social norms of interaction. This study examined pre-service teachers' (PSTs) practicum reflections for the norms of interaction they promoted with fourth grade students to solve an engineering design problem. The results indicated that, overall, the PSTs emphasized norms prompting students to share their individual ideas and reasons for a proposed design with less focus on norms promoting students' attention to and negotiation with other's contributions. However, there was variation among the PSTs in their encouragement of student discourse norms. We provide a case study describing the decisions of one PST who addressed the full range of norms of interaction. These findings suggest areas of focus for teacher educators when preparing elementary PSTs for the new standards expectations of student collaboration in scientific meaning making and engineering problem-solving.

Exploring Pre-service Teachers' Pedagogical Content Knowledge for NGSS practices through Curriculum Critique and Revision Task
Tejaswini S. Dalvi, Universty of Massachusetts
Elaine M. Silva Mangiante, Salve Regina University
Kristen B. Wendell, Tufts University
ABSTRACT:
With engineering elevated to a new level in elementary science education standards, the pre-service teacher candidates need to be prepared for teaching both science and engineering. There is a need for approaches to prepare novice elementary teachers to teach science inquiry and engineering design while supporting student reasoning in classroom. And provide support to be able to adapt and use written curriculum materials as resources. In particular, teacher educators need to know how to support pre service teachers develop an understanding of the practices of science and engineering, and plan and adapt for enactment of these practices in classroom. This paper presents Curriculum Critique and Revision (CCR), an assessment and research tool, designed for PSTs to critique an existing written curriculum excerpt for its inclusion of science and engineering practices and then suggest revisions or extensions to include any omitted practices. We investigate how PSTs perform on the CCR before and after, a science and engineering teaching methods course and report on PSTs understanding of the practices. Thereby informing teacher educators of specific needs in preparing PSTs to adapt existing curriculum materials as resources for planning lessons aligned with the new NGSS practices.

Making Sense of the NGSS: Preservice Teachers' Practical Knowledge
Deborah L. Hanuscin, University of Missouri, Columbia
Laura Zangori, University of Missouri
ABSTRACT:
Just as new standards call for change in what students learn and how they are taught, teacher education programs must reconsider what teacher candidates will learn about new standards and how to implement them. There is very little research on how prospective teachers deal with standards, though some literature suggests important differences between novices and experienced teachers when it comes to reform - both in their attitudes toward standards and their ability to integrate their knowledge, beliefs, and practice. Our study examines how prospective elementary teachers made sense of the Next Generation Science Standards (NGSS) in the context of a science methods course and innovative field experience. Using the concept of 'practical knowledge' as a framework, we present three themes related to prospective teachers' beliefs and practices implementing the standards: (a) as a useful guide for planning and designing instruction, (b) as a benchmark for student and self-evaluation, and (c) as an achievable vision for teaching and learning. As such, this work makes an important contribution towards understanding how prospective teachers make sense of the NGSS, and suggests actions teacher educators can take to support the development of prospective teachers' practical knowledge of the NGSS.

Strand 7: Pre-service Science Teacher Education
Preservice Teacher Learning in Lab and Physics Settings
1:15pm-2:45pm, HBG Convention Center 007D
Presider: May Lee, Michigan State University

Assessing the Professional Vision of Pre-service Teachers in the Student-lab
Florian Treisch, University of Würzburg
Thomas Trefzger, University of Würzburg
ABSTRACT:
In 2010 the student-lab seminar was integrated in the physics teacher education at the University of Würzburg. The participating pre-service teachers create experimental stations for students to a given teaching unit like optics or electrodynamics. After this period of preparation (ten weeks), about four school classes will attend the course and the pre-service teachers will teach the students in a microteaching setting on the experimental stations. After every run, the pre-service teachers will reflect their teaching peer-to-peer and with the instructors. The research interest focuses on the development of the professional vision (PV) of the pre-service teachers. This is the ability to direct attention to relevant classroom elements and to reason about them. During the teaching acts half of the stations will be filmed to get video reflections after every visit. With this setting it is possible to compare the changes in PV between the group with and without the video reflection. In addition the two groups will be compared with a baseline existing of preservice teachers who do not joint the course. To assess the PV we use the Observer-Tool in a pre-post-design. In my talk you will see the results of four semesters (N = 90) of research.

Comparison of Pre-service Physics Teachers' Conceptual Understanding in Model-Based Scientific Inquiry and Scientific Inquiry Environments
Feral Ogan-Bekiroglu, Marmara University
Arzu Arslan-Buyruk, Sebahattin Zaim University
ABSTRACT:
Although researchers argue that situating modelling in inquiry frames is effective for learning science content and understanding scientific practices, there are relatively small number of studies that have closely examined effects of model based inquiry on learning. Consequently, the research question explored in this current study is as follows: Are there measurable differences in pre-service teachers' conceptual learning of dynamics when comparing two physics classes instructed with model-based inquiry and inquiry? True-experimental design using quantitative and qualitative research methods was carried out for the study. Participants were 22 senior pre-service physics teachers. Both the experimental and control classes were studied the same dynamics concepts with the same instructor. Findings presented that model-based inquiry supported the learning process. When students were given a chance to generate and revise models during inquiry, they tended to select the scientific choices of the questions, made better explanations for their choices and reached higher level of conceptual understanding. Qualitative analyses showed that the students providing theoretical background for their experiments, specifying variables and the relationships among them, and proposing precise hypotheses made improvement in their learning. The study suggests that curriculum developers and teacher educators would disseminate model-based inquiry through science programs and teacher education.

Listening and Responding to Student Thinking - The Importance of Epistemic Empathy
Lama Jaber, Florida State University
Sherry A. Southerland, Florida State University
Felisha Dake, Florida State University
ABSTRACT:
There is increased attention to the importance of responsive teaching to promote students' intellectual agency and sense-making in science. This responsiveness entails that teachers attend to students' reasoning and develop instructional moves that build on students' ideas, interests, and questions. Although many studies have explored how teachers attend and respond to students in the classroom, here we examine underlying dynamics behind teachers' responsiveness, asking: how do preservice teachers come to identify with students' ways of thinking to make sense of their ideas? We discuss findings from an undergraduate education course where every week teachers watched videos of student inquiry and wrote analyses of students' ideas. Throughout the course, we noticed teachers' developing tendency to take on learners' perspectives and express curiosity about their ideas. We refer to this orientation as "epistemic empathy" to characterize how teachers moved beyond their comfortable ways of thinking and took learners' perspectives seriously. Here, we discuss findings from pre and post written video analyses to argue that teachers have various empathetic resources they could leverage to make sense of student thinking. We suggest that epistemic empathy is a central dynamic in teachers' uptake of students' ideas in instruction and we discuss implications for teacher education.

Practical and Discursive Consciousness of Novice Science Teachers when Facing the Science Classes
Mauricio Pietrocola, University of Sao Paulo
Kellys R. Saucedo, Universidade de São Paulo
Samuel M. Schnorr, University of São Paulo
Juliana Maia, University of Sao Paulo

Antonio Carlos Mometti, University of São Paulo

ABSTRACT:
The goal of this work is to understand the limits and possibilities of teachers' preparations during pre-service courses in regard to the activities they performance at schools. Recent works have shown how important is to study the passage of novice teacher from the college to the school. In this work we have studied a quartet of science students during a practical activity in which they have been asked to performance an innovative activity in a physics class. The focus was to see how students implement a designed lesson planned during a pre-service course and study their performance in terms of fit or not fit the expected goals. The analyzes was focused on the students understanding of the activity they have made and about the context where they are immersed and the level of conscience they attain. The findings deal with the influence of previous educational activities in the performance of the students and the lack of consciousness they attaint in analyzing the activities they have done. The different levels of that came during the process of becoming a teacher could help develop curriculum more adapted to prepare new teachers to the professional duties and challenges they will face.

Strand 8: In-service Science Teacher Education
Symposium: Identity at the Crossroads Intersections of Teacher Identity and Contexts of Teaching, Learning and Living
1:15pm-2:45pm, HBG Convention Center 006B
Presenters:
Jennifer Adams, Booklyn College, CUNY
Susan McCullough, Graduate Center, CUNY
Atasi Das, CUNY
La Toya Strong, CUNY
Sabrina Hussain, Urban Advantage
Cristina A. Trowbridge, American Museum of Natural History

ABSTRACT:
In this symposium we interrogate the relationships between teacher learning and teacher-identity through examining the sociocultural contexts of learning to teach and teaching. Drawing our data from teachers in a large, urban district we describe how teacher learning experiences, in particular in informal science education settings, and contexts of schools influence teacher identity, including practice, positioning and discourses about teaching. We examine racial storylines of teachers, reflective practice and self efficacy in teacher leaders, and silences all affording a more nuanced view of learning to teach and teacher identity as situated in the complex lives of teachers and schools. This session will be of interest to researchers, teacher-educators, teachers and informal science researchers and educators.

Strand 8: In-service Science Teacher Education
PCK
1:15pm-2:45pm, HBG Convention Center 008A
Presider: Justina A. Ogodo, The University of Alabama

Challenges of Teachers Developing and Implementing Practices-based Student Investigations
Kathleen Hill, Pennsylvania State University
Matthew Johnson, Pennsylvania State University
Amanda Smith, Pennsylvania State University
Annmarie R. Ward, Pennsylvania State University

ABSTRACT:
Recent STEM education reforms suggest that teachers should teach disciplinary ideas using the practices of experts. Teachers must have sufficient understanding of the practices of scientists and engineers. One strategy to increase teachers' knowledge of these practices is a research immersion experience coupled with professional development. This study investigated the degree to which six teachers were able to translate their summer research experiences into classroom instruction. Data collected included teacher work products, a survey, a questionnaire, and field notes. Analyses indicated that the classroom research projects (CLRPs) developed by the teachers incorporated many of the practices of their summer research experiences. In addition, the teachers faced challenges in implementing their CLRPs within their teaching context. Three significant points arise from these findings: (1) with support, the teachers were able to develop practices-based curriculum; (2) the teachers' discontentment levels were not related to their ability to develop and implement practices-based instruction; and (3) district-directed scope and sequences, lack of sufficient resources, and high stakes testing were viewed as barriers to implementation. These findings indicate that teachers can be supported in using the practices to teach content, which can inform policy and professional development for teachers in the area of practices-based instruction.

Developing Design Expertise through a Teacher-Scientist Partnership Professional Development Program
Julie Bokor, University of Florida

Kent J. Crippen, University of Florida

ABSTRACT:

Teachers are tasked with designing learning experiences for their students and are expected to translate professional development experiences into classroom practice. However, there is little research on how and to what extent teachers engage in the process of design, particularly translating a teacher-scientist partnership professional development (TSP PD) program into the classroom. The current study draws from the work of Huizinga (2014) to consider design expertise as a complex set of knowledge and skills, specifically the integration of subject matter knowledge (SMK), pedagogical content knowledge (PCK), and curriculum design knowledge (CDK) and explores how teachers' engagement with the activity structures and design supports of a TSP PD program influences their professional knowledge and design expertise. Design-based research and conjecture mapping are used to frame the inquiry of this single-case method study. Although quantitative measures of SMK and PCK did not indicate learning gains, the final curricular products reveal the development of design expertise. Additionally, teachers report an increase in their CDK as a result of the TSP PD program. Each teacher demonstrates a different level of design expertise reflective of their professional knowledge integration, personal resources, and value placed on each of the activity structures and design supports.

Does it Matter to be Informed - Naive or not? An Example of Professional Development Program about NOS

Cigdem Han Tosunoglu, Marmara University
Nihal Dogan, Abant Izzet Baysal University
Gizem Ertugrul, Abant Izzet Baysal University
Ferah OZER, Abant Izzet Baysal University
Serhat Irez, Marmara University
Gultekin Cakmakci, Hacettepe University
Yalcin Yalaki, Hacettepe University

ABSTRACT:

Much of the curriculum change that has occurred in science since 1950 has not been successful in the long term in Turkey, not having any real impact on what is taught in the classroom. The new National science curriculum reforms emphasize on scientific literacy and science for all future citizens. Hence the science educators focused on the context and social aspects of science, and its relevance to everyday life. However in order to be able to do that, primarily teachers should have the adequate NOS views and sufficient pedagogical content knowledge about NOS (NOC-PCK) in addition to other knowledge bases. Thus, this study investigated the effectiveness of professional development program on teachers' classroom practices through the video records and how teachers' views about nature of science affect their practices in classroom instructions. The results indicate that teachers views of NOS wasn't impressionable, factors as gender, academic degree, professional experience, experience about NOS or HOS courses and the number of activities they implemented are found to be effective to translate NOS concepts in order to change students' views. These results highlight the importance of key characteristics of teachers that challenge a simple portrayal of teaching nature of science and the teachers' classroom practice

The Development of Teachers' Topic-Specific PCK in Stoichiometry through Participation in a Learning Study

Stephen A. Malcolm, University of the Witwatersrand
Marissa S. Rollnick, Wits University
Elizabeth Mavhunga, University of Witwaterrand

ABSTRACT:

Stoichiometry, which deals with the quantitative aspects of chemistry is considered difficult to teach and difficult for students to grasp. Many teachers focus on the algorithmic aspects rather than teaching conceptually. Based on the performance of students in this topic in the country in which this study was conducted and the results of an exploratory study to measure teachers' PCK in the topic which highlighted the problems a professional development intervention was designed using the components of the topic-specific PCK model. The intervention was a collaborative learning study and investigated the development of three teachers' PCK who participated in a learning study. A lesson of the mole concept was collaboratively planned and taught and the teachers' PCK in stoichiometry was measured using the instrument designed for this purpose. The pre-testing and post-testing indicated a promising improvement in some of the components of the teachers' PCK in the topic of stoichiometry which was corroborated by the qualitative analysis of the meetings and pre-lesson interviews conducted as part of the learning study. However the participants showed no improvement related to conceptual teaching strategies in other aspects of teaching stoichiometry.

Strand 10: Curriculum, Evaluation, and Assessment

Related Paper Set: Supporting Secondary Students' Modeling Practice Using a Web-based Modeling Tool

1:15pm-2:45pm, HBG Convention Center 006C

Presider: Joseph S. Krajcik, Michigan State University

ABSTRACT:

Modeling tools can help students understand emergent phenomena related to complex systems. To scaffold students' learning with models, our related paper set presents (i) the development of a web-based systems modeling tool, as well as (ii) the iterative process used to design middle and high school units that make use of the new modeling tool. Results from usability studies and classroom pilots shed light on how the tool can help students understand systems and the relationships between components within a system. We

then review the collaborative process between teachers and researchers that guided the development of NGSS-aligned, project-based learning units. To explore how students learn with the new software, we present findings from the initial enactment of the new tool in a unit on ocean acidification, examining the nature of students' internal (mental) models and their external expressions. These findings are extended through a teacher's in-depth discussion of the models her students developed during a water quality unit. Finally, we explore how the modeling tool and the accompanying units contributed to students' engagement.

Designing a Systems Modeling Tool That is Accessible to Secondary Students
Daniel N. Damelin, The Concord Consortium
Joseph S. Krajcik, Michigan State University
William Finzer, The Concord Consortium

A Collaborative Model for the Development of NGSS-aligned Units that Incorporates Student Model Building
Steven Roderick, The Concord Consortium

Explanations and Relationships in Students' Mental and External Models
Li Ke, Michigan State University
A. Lynn Stephens, University of Massachusetts

Using Technologies to Support Middle School Students in Building Models of Stream Water Quality
Ann M. Novak, Greenhills School

Using a Modeling Tool and Project-based Learning Materials to Promote Students' Classroom Engagement
Tom Bielik, Michigan State University
Sebastian T. Opitz, Michigan State University

Strand 11: Cultural, Social, and Gender Issues
Leveraging Diversity in STEM Teaching and Learning
1:15pm-2:45pm, HBG Convention Center 008B
Presider: Natalie S. King, Georgia State University

Beliefs and Attitudes Toward STEM: Increasing Interest in STEM for Female Students of Color
Elizabeth Crotty, University of Minnesota
Felicia Leammukda, University of Minnesota
Jeanna Wieselmann, University of Minnesota
Gillian Roehrig, University of Minnesota
ABSTRACT:
Research has indicated that attitudes of females of color toward STEM fields tend to become more negative from elementary to college. These changes in attitudes eventually influence their career choices (Riegle-Crumb, Moore, & Ramos-Wada, 2010). As a result, females of color are underrepresented in STEM fields (National Science Foundation [NSF], 2015). In order to ensure that all students have the opportunity to pursue STEM careers, educators need to find ways to increase interest for a broader audience of students. This mixed methods study examines the effect of novel STEM curricula on improving the attitudes of these students toward STEM. The authors highlight characteristics of STEM curricula that appeal to female students of color. The results of this study indicate that participation in these STEM units showed positive trends for the students in this study. The authors of this study contend that framing engineering as a helping field might be beneficial. Making explicit connections to what engineering is and what engineers do throughout STEM units might prove to be important. Finally, promoting the relevance of STEM knowledge and addressing common misconceptions about engineering could further improve the interest in STEM for female students of color.

Factors Influencing Student Interest in STEM Fields
Melinda A. Hamilton, University of Idaho
Susan Stauffer, University of Idaho
ABSTRACT:
Numbers of underrepresented students in STEM fields are low. These students comprise an untapped resource that can only be realized if the students have interest in pursuing STEM careers. We undertook a study that investigated the complexity of cultural dimensions that shape student interest in STEM with a goal of understanding drivers of under-represented students' aspirations. Seventh and 10th grade students across Idaho were surveyed in 2012 and again in 2015 when they were in 10th grade and one-year post-high school. A decline in interest in math was evident throughout middle and high school. Attitudes toward math demonstrated that while girls still like math in middle school, to some extent even more than boys, their interest drops dramatically between 7th and 10th grade. Similar to national trends, interest in math and science was demonstrably low for Hispanic students. Even though students perceived science and engineering careers as exciting, there was little interest in pursuing these careers. Interest in engineering was alarmingly low in all populations, less than 9% and even lower for female and Hispanic respondents. The results presented suggest

that attitude about math is an important factor in student education and career aspirations and math interventions may be critical to engaging under-represented students in STEM fields.

Teachers' Modifications of an Integrated STEM Lesson with Intent to Incorporate Cultural Relevance
Felicia Leammukda, University of Minnesota
Julie C. Brown, University of Minnesota
Emily A. Dare, Michigan Technological University
Paula S. Rozowa, University of Minnesota
Gillian Roehrig, University of Minnesota
ABSTRACT:
Research shows that interest and achievement is lower in science among Blacks and Hispanics compared to White students. However, when instruction is culturally relevant to students' lives, they show greater enthusiasm and academic achievement compared to using traditional approaches alone. Unfortunately, many science teachers lack the skills and knowledge to modify their curriculum and make it culturally relevant for their students. In this study, the authors investigated how teachers enrolled in a four-week induction course on equitable science teaching modified an existing science, technology, engineering, and mathematics (STEM) lesson plan intending to make it culturally relevant for their students. Findings showed that novice teachers were able to modify a lesson of an existing curriculum in such a way that it included more indicators of culturally relevant pedagogy (CRP) and incorporated their students' funds of knowledge (FoK) into their lesson planning. Examples of how teachers modified the lesson plan included inviting parents to share their expertise and investigating societal groups who live in flood-prone areas.

Leveraging Students' Everyday Engineering Practices in the Science Classroom
Veronica McGowan, University of Washington
Philip L. Bell, University of Washington
ABSTRACT:
The Next Generation Science Standards promote engineering as a pathway to broadening STEM participation for students from non-dominant groups, noting that engineering gives students the opportunity to deepen their science knowledge by engaging them in problem-solving practices around locally-relevant issues. However, this perspective does not take into account that most elementary school teachers use pre-designed kits and curricula to ground their science and engineering instruction. These pre-designed units are intended for scale rather than context, and rarely incorporate the everyday knowledge, expertise, and practices, known as "community funds of knowledge" that each student brings with them to the classroom. 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.

Strand 12: Educational Technology
Virtual and Augmented Reality
1:15pm-2:45pm, Hyatt Crockett AB
Presider: Len Annetta, East Carolina University

Cognitive Demand and Dynamics: Comparison of Virtual and Real Laboratories in Science Education via fNIRs
Richard Lamb, State University of New York At Buffalo
Len Annetta, East Carolina University
Jonah B. Firestone, Washington State University Tri-Cities
Pavlo D. Antonenko, University of Florida
Maureen Schmitter-Edgecombe, Washington State University
Xiufeng Liu, State University of New York, Buffalo
Ren Lie, State University of New York, Buffalo
ABSTRACT:
The purpose of this study was to investigate differences in the level of hemodynamic response (a proxy for 'cognitive demand' and 'cognitive dynamics') as it related to three different pedagogical approaches of teaching the processes of DNA extraction. Functional near-infrared spectroscopy (fNIRs) technology was used in this study to examine hemodynamic localization and relative cognitive dynamics and demand associated with each condition. The hypothesis was that students in the Serious Educational Game group would have a greater number of localized responses, yet the responses would be less intensive in the frontal cortical regions than students in the traditional group. In addition to examination of cognitive demand and dynamics via hemodynamic activation, learning gains were triangulated via correlation to content based pretest and posttest gain scores. Results suggest that the group using the virtual laboratory in the form of a Serious Educational Game had a significantly higher score increase on the posttest compared to the traditional group. Analysis of fNIRs data indicates that there is statistically significantly more hemodynamic response in the frontal cortex when students are playing the educational game. These results suggest that realistic game based environments and 'real-life' laboratory activities produce similar amounts of processing and learning.

Designing Gestures to Control a Simulation for the Causes of Seasons
Nathan Kimball, Concord Consortium
Christina Silliman, University of Illinois, Urbana Champaign
Robb Lindgren, University of Illinois, Urbana, Champaign
ABSTRACT:
Our study investigates the role of body movement or gestures of the hands in the development of students' reasoning with difficult science concepts, particularly concepts that underlie phenomena that have unseen structures and unobservable mechanisms. One such phenomena, and our focus here, is the cause of the seasons, a complex and unobservable system involving the Earth's tilt and the consequential variation of the angle of direct sunlight across a point on the Earth's surface throughout year. This study has two overarching goals. The first goal is to identify gestures that support the development of causal explanations of this phenomenon. The second goal seeks to apply gestures that are helpful in building explanations to the control of a computer simulation of the Earth-sun system using gesture-input technologies. This paper will focus on the second goal by examining the gesture-based control of our seasons simulation. We will describe our rationale for design as informed by data from students and how we have reconciled our findings about generative explanatory gestures with the limitations of gesture-input technologies. We will discuss our findings from data collected from student use.

Effect of Hands-on and Hands-off Collaborative Augmented Reality Activities on Chemistry Learning and Interest
Shih-Yeh Chen, National Taiwan Normal University
Shiang-Yao Liu, National Taiwan Normal University
ABSTRACT:
The utilization of Augmented Reality (AR) in education is a universal trend to improve students' learning outcomes and affective factors. Hands-on activities have caught educators' attention for its effectiveness on learning, yet some contradictories are existed. The purpose of this study was to investigate the influence of hands-on and hands-off AR learning activities on students' conceptual understandings and interests in chemistry. There were 104 students in grade 9 recruited in this study using quasi-experimental design by comparing their pre-/post-test via paired t test and analysis of covariate (ANCOVA), and interviewing students about what they perceived toward the collaborative AR learning activities. Results demonstrated that, in addition to the general improvement on conceptual understandings and interests in chemistry, the students in hands-on learning group performed significantly better on the chemical reaction component and situational interest dimension than those of hands-off learning group after the AR activities. According to analysis of interview responses, students were satisfied with collaborative learning in the AR activities. Accordingly, the use of AR device along with collaborative learning approach may serve as an effective teaching strategy in chemistry.

Relating Cognitive Development to Perceptions of Virtual Presence in 3-D, Haptic-enabled, Virtual Reality Science Instruction
Rebecca Hite, Texas Tech University
M. Gail Jones, North Carolina State University
Gina Childers, University of North Georgia
Megan Ennes, NC State University
Katherine Chesnutt, North Carolina State University
Mariana Pereyra, North Carolina State University
Emily Cayton, North Carolina State University
ABSTRACT:
This study investigated possible relationships between middle and high school students' cognitive development and perceptions of presence with a 3-dimensional (3-D), haptic-enabled (HE), virtual reality (VR) system. Student participants completed a pedagogically appropriate learning activity on the human heart using a 3-D, HE VR technology system. Participants were surveyed to evaluate their perceptions of virtual presence. This self-report consisted of Likert-scale items inquiring to users' perceived levels of control, distraction, realism, and overall sensory engagement. Participant's level of cognitive development was evaluated using an inventory of Piagetian tasks. Perceptions of virtual presence were not significantly different between middle and high school levels, however middle grade students' cognitive development in spatial rotation and angular geometry was positively correlated to their presence scores in control and negatively correlated to their presence scores in distraction. Results suggest that developmental aspects contribute to younger users' perceptions of virtual presence.

Strand 13: History, Philosophy, and Sociology of Science
Nature and Philosophy of Science in Science Education
1:15pm-2:45pm, Hyatt Republic ABC
Presider: Zoubeida R. Dagher, University of Delaware

Consistency of Nature of Science Views
Rola Khishfe, American University of Beirut
ABSTRACT:

The purpose of the investigation was to investigate the consistency of NOS views among high school students across different scientific and socioscientific contexts. A total of 261 high school students from eight different schools in Lebanon participated in the investigation. The schools were selected based on different geographical areas in Lebanon and the principals' consent to participate in the study. The investigation used a qualitative design to compare the responses of students across different contexts/topics. All the participants completed a five-item open-ended questionnaire, which includes five topics addressing scientific and socioscientific contexts. The items of the questionnaire addressed the empirical, tentative, and subjective aspects of NOS. Qualitative analysis was conducted to answer the research questions. Results showed that participants' views of the emphasized NOS aspects were mostly inconsistent. Plus, there was variance in participants' views of NOS between scientific and socioscientific issues. Discussion of the results related to differential developmental progression, contextual factors, social constructivist perspective, different domains of knowledge, and students' individual differences.

Developing 7th Grade Students' Nature of Science Views with Explicit Reflective Approach
Kayahan Ince, Institute of Educational Sciences
Sinan Özgelen, Mersin University
ABSTRACT:
The purposes of this study were to explore understanding of student's NOS views during the explicit-reflective activities and at the end of the process are to determine students' views of the changing nature of science. For this purpose, eight NOS activities were held in science courses with a total number of 35 seventh grade students. Qualitative approach was used to in this research determine students' views of the changing nature of science. Researcher collected data with VNOS-D, interviews to explore student's nature of science views. Then, during the research, reflection papers collected to understand students experience with the intervention and see the development of views on nature of science each aspects. According to pretest results, students are determined almost entirely inadequate in view declaring six NOS aspects. As a result, many students develop their NOS views from weak to adequate level. Additionally, according to the study results, the students of the applied activity were found to be effective in improving the student's NOS views. Otherwise, at the end students developed their perspectives about NOS. However, 3 months after instruction, the students were again interviewed and answered VNOS-D and several of the students reverted back to their earlier views. Keywords: Nature of science, explicit-reflective approach, seventh grade students

Does NOS Understanding Foster Science Content Learning? Impact of an Epistemologically Informed Unit About Energy
Hanno Michel, Leibniz Institute for Science and Mathematics Education, Kiel
Irene Neumann, Leibniz Institute for Science and Mathematics Education, Kiel
ABSTRACT:
For a long time, nature of science (NOS) has been promoted an important part of scientific literacy, for its inherent value as well as for its potential role as a prerequisite for learning science content (Driver et al., 1996; Lederman, 2007). However, there is a lack of systematic investigations, which clarify the relations between NOS instruction and learning of science concepts. The present study provides information about the impact of an epistemologically informed teaching unit about energy, which concatenates NOS aspects and epistemological aspects of energy (EAE), on students' learning. 207 students from grades 10 to 12 participated in one of the two units, respectively. Results indicate that the epistemologically informed teaching unit (treatment group) could enhance students' acquisition of both NOS understanding and an understanding of EAE, when compared to a conventional unit on energy (control group). Thus, in order to let students perceive the value of energy as a central theoretical framework in science, as well as in everyday life, which can be applied to manifold different phenomena and problems, an epistemologically informed approach towards the concept, as it is presented in this study, appears highly supportive.

What Does Philosophy Education Have to Say About Science Education?
Caio S. Nagayoshi, University of São Paulo
Hamilton Haddad Jr., University of São Paulo
ABSTRACT:
There is a consensus regarding the importance of the contribution of philosophy of science to science education. At the same time, there is much debate on how exactly such contribuition should occur. In many countries, philosophy education has a traditional place in school, which has fostered research in this field. We present the case of Brazil, where philosophy education in high-school is mandatory, and the ideias of two influential authors in that country. By analyzing their views on philosophy education, we find elements to reflect on the role of philosophy of science and science education. We conclude with an invitation to science educators and science education researchers to explore the research in philosophy education in different countries and languages, as it can contribute to science education.

Strand 14: Environmental Education
Symposium: Promoting Student-led Research-informed Socio-political Actions on Socio-scientific Problems: Inter/Trans-national Perspectives
1:15pm-2:45pm, Hyatt Travis CD
Presenters:

John L. Bencze, University of Toronto
Mirjan Krstovic, Peel District School Board, Mississauga, ON
Isabel G. Martins, Universidade Federal do Rio de Janeiro
Lyn Carter, Australian Catholic University
Jenny L. Martin, Australian Catholic University
Chantal Pouliot, Universite Laval
Audrey Groleau, Université du Québec à Trois-Rivières and Université Laval
Matthew Weinstein, University of Washington
Ralph Levinson, University College London

ABSTRACT

There is a consensus regarding the importance of the contribution of philosophy of science to science education. At the same time, there is much debate on how exactly such contribuition should occur. In many countries, philosophy education has a traditional place in school, which has fostered research in this field. We present the case of Brazil, where philosophy education in high-school is mandatory, and the ideias of two influential authors in that country. By analyzing their views on philosophy education, we find elements to reflect on the role of philosophy of science and science education. We conclude with an invitation to science educators and science education researchers to explore the research in philosophy education in different countries and languages, as it can contribute to science education.

Concurrent Session #6A
Poster Session
3:15pm – 4:15pm

Poster Session A
3:15pm – 4:15pm, Hyatt Texas Ballroom A, B, and C

Strand 1: Science Learning, Understanding and Conceptual Change
Poster Session A
3:15pm – 4:15pm, Hyatt Texas Ballroom A, B, and C

Using Models as Tools for Scientific Reasoning in Chemistry Education
Marvin Rost, Humboldt-Universität zu Berlin
Rüdiger Tiemann, Humboldt-Universität Zu Berlin

ABSTRACT:

This study describes an empirical approach to link the process of scientific reasoning to using models in chemistry education in secondary school classes. A definition of models as epistemic tools, consisting of four components (elements, relations, operations, rules) is given and the connection between models and scientific reasoning is expained. The conducted study with students from Germany (N = 48) via a questionnaire (open-ended & multiple-choice items) and think-aloud protocols resulted in two main findings. First, the data shows an understanding of models as visualizing tools for sub-microscopic objects by the students. Second, if the four model components are used for the cause of scientific reasoning processes, they seem to include different levels of difficulty, which could be explained by an ascending degree of necessary abstraction. The overall results are discussed against the background of future studies. Additionally, it is argued that empirical research on model-based science education needs further discussion, as it is one of the fundamental modes of both scientific theory and practice.

Analysis of Middle School Students' Representational Competences on the Electric Current
Hye-Gyoung Yoon, Chuncheon National University of Education
Kwanghee Jo, Chosun University
Hunkoog Jho, Dankook University

ABSTRACT:

This study aimed at investigating middle school students' representational competence on the electric current and their difficulties in understanding the concept. The questionnaire was developed to examine students' representational competence categorized into interpretation, construction, and application. A total of 99 students were asked to answer the questionnaire. In terms of interpretation of visual representation, the students were confused with charges, electrons and electric poles and did not match scientific terms with representations properly. As for the construction of visual representation, the students had difficulties in expressing the movement of negative charges in the wire and tended to draw the current with only one kind of charge. As well, some of their representations were similar to the electrostatic induction even in the electro-dynamic conditions. Those characteristics of current representation were the same in application context. Based on the research finding, this study gave some pedagogical implications for the effective teaching of electricity in terms of visual representations.

Comparing 3rd and 5th Grade Students' Model-Based Explanations about Water
Tina Vo, University of Nebraska, Lincoln
Cory T. Forbes, University of Nebraska, Lincoln
Laura Zangori, University of Missouri
Christina V. Schwarz, Michigan State University
ABSTRACT:
Water's role across different earth systems is a fundamental concept within the Next Generation Science Standards (NGSS Lead States, 2013) for earth science and highlighted throughout the K-12 standards. Learning progressions focused on helping elementary students learn about water systems and engage in scientific modeling have helped identify levels of knowledge elementary students will likely progress through as they develop conceptual knowledge about water. However, such learning progressions are typically anchored at the upper elementary grades (5th). Our recent research has explored 3rd-grade students' model-based reasoning about water and led to the development of a set of integrated, empirically grounded learning performances for 3rd graders learning about water. In this parallel mixed methods study, we explore how these learning performances, developed for lower elementary students, translate to upper elementary grades. While it might be assumed that upper elementary students would generate more effective model-based explanations across all performance levels, study results did not support this assumption. We found while 5th grade students generated more accurate model-based explanations for water overall, there were specific topics where 3rd grade students were able to outperform their 5th grade counter parts on certain sub dimensions of the learning performances.

Creating an Acid Base Learning Progression
Heather C. Thompson, Texas Christian University
Erika Zimmermann, Texas Christian University
ABSTRACT:
What does a learning progression on the acid-base concept look like and does it reflect current scientific understanding? Participants in this study were 156 students, from one chemistry teacher at a large urban school. Participants received the pre- and post-assessment (same document) and were asked to complete it on a volunteer basis. Of those students, 115 (73.7%) pre- and post-assessments could be analyzed. Most student in the pre-assessment fell into the lower levels of understanding. Upon completion of the acid base unit, some student achieve the higher levels of understand. This was expected considering that the lower levels are typically taught in elementary and middle school and the level three is taught at the high school level. In the end, we determined that our proposed learning progression of student understanding mirrors the scientific development of the acid-base concept.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

"This is Really Frying my Brain!" How Affect Supports Inquiry in an Online Learning Environment
Jennifer A. Radoff, Tufts University
Lama Jaber, Florida State University
Elizabeth Hufnagel, University of Maine
Vesal Dini, Tufts University
ABSTRACT:
In this study, we examine the ways in which affect took shape and functioned in teachers' sense-making around a puzzling phenomenon, in a blended-online professional development course. Drawing from grounded theory, we identified affective expressions in participants' posts using explicit and implicit discourse markers, and analyzed the ways in which these expressions became consequential to participants' inquiry. Four functions of affective expressions emerged from our analysis: A) making space for and legitimizing feelings of vulnerability and confusion, B) inviting new conceptual substance C) driving new questions about the physical phenomenon, and D) motivating action such as experimentation to test out ideas or figure something out. Using a sequential series of posts, we illustrate how these four functions supported teachers' productive disciplinary engagement (Engle & Conant, 2002) both individually and as a collective. This work contributes to the field's understanding of disciplinary engagement by highlighting the role of affect in learners' inquiry in online spaces. The study also has implications for the ways in which instructors of online courses can make space for and orient to their students' affect.

Exploring Different Achievers' Inquiry Competency and Inquiry Understanding under Inquiry-based Instruction
Yen-Ruey Kuo, National Changhua University of Education
Hsiao-Lin Tuan, National Changhua University of Education
Chi-Chin Chin, National Taichung University of Education
ABSTRACT:
This paper aimed to investigate Grade 8 high, middle and low achievers' inquiry competency and understanding of inquiry under guided inquiry instruction in a rural school in central Taiwan. Quantitatively and qualitatively mixed methods design was adopted. There were experimental (n=30) and control groups (n=32), and the experimental group used guided inquiry instruction in science club classes, while the samples in control group were from other non-science clubs. 12 guided inquiry units (45-135 min each)

emphasizing on showing phenomena, proposing assumptions, designing experiments, operating experiments, analyzing data and discussing with peers was instructed in experimental group. A questionnaire measuring students' inquiry competency and understanding of inquiry was administered in both groups right before and after the intervention. The teacher in the experimental group wrote reflective journals after conducting each unit and had a meeting with researchers after finishing all units. The results showed high achievers in the experimental group had better inquiry competency than the counterparts in the control group, and could apply their ability to design experiments in different contexts. Middle and low achievers under intervention had better understanding of inquiry than those in the control group, and they improved their understanding of different types of variables.

Exploring the Gender Gap in STEM Career Participation
Matthew A. Mendicino, University of Georgia
ABSTRACT:
In the United States, females are strikingly under-represented in the STEM workforce. The postsecondary coursework essential to obtaining a career within STEM is daunting. Introductory college chemistry, in particular, is widely regarded as a significant "gatekeeper" for students aspiring to a career in a STEM discipline. Lack of academic success in the course leads many to abandon their goals of working in a STEM career. In this study, four female undergraduate students enrolled at a large southeastern university were interviewed during their second semester of introductory chemistry, aiming to understand their experiences within the course to gain insight into the shortage of females in STEM careers. This study utilized Stake's case methodology to investigate the student cases. Cases were subsequently analyzed using Strauss' system of coding to determine salient themes. This study aimed to answer the following research questions: 1.) How do female undergraduate students develop an interest in learning chemistry? 2.) How do female undergraduate students' beliefs about the gatekeeping function of introductory chemistry influence their pursuit of a scientific career? 3.) What aspects of the curriculum and instruction of introductory chemistry do female undergraduate students believe facilitates or constrains their learning of chemistry?.

Instruction, Creativity and Facilitating Reasoning: An Exploratory Study
Bruce G. Waldrip, University of Tasmania
Ari Widodo, Indonesian University of Education
John D. Kenny, University of Tasmania
ABSTRACT:
This paper is derived from a larger study that explored how teachers, utilised creative dispositions (Lucas, Claxton & Spencer, 2012) and the reasoning process in their classrooms. Interviews, artefacts and an analysis of classroom videos were used to analyse the proportion of time spent on different reasoning process (Tytler, Prain, Hubber & Waldrip, 2013). Shifts in creative disposition were detected in classrooms. Some of the creative dispositions were more evident in certain classes. To develop reasoning the Australian teachers expected their students to construct coherent arguments by making claims, justifying the robustness of their claims, applying their claims to new settings and thinking of alterative explanations. The Indonesian teachers, by comparison, tended to emphasise students using their imagination and challenging assumptions made by students. We conclude that the observed differences in the creative dispositions emphasised helped to explain why the reasoning process was not sequential and supports Tyler and Prain's (2010) view that learning is somewhat a fluid process. We suggest that teachers moving between creative dispositions to facilitate a change in reasoning, can explain some of this process.

Student Attitudes and Achievement in Middle School, Project-based Learning: What Do Students Do with Autonomy?
Katherine L. Supanich, Hope College
Lara Iaderosa, Hope College
Julie Isola, Hope College
Carly Sommavilla, Hope College
Stephen C. Scogin, Hope College
ABSTRACT:
STREAM School is a nontraditional, project-based learning program at a rural middle school. Students in STREAM School are given high levels of autonomy to facilitate increased student engagement in projects. Previous research has shown that student control and freedom often lead to higher levels of engagement in projects (Bowman, 2011). In order to obtain a holistic understanding of students' experiences of the seventh-grade STREAM program, this research utilized a convergent-parallel mixed methods design (Creswell & Plano-Clark, 2011). Qualitative data were analyzed using grounded theory (Strauss & Corbin, 1990). Various descriptive and inferential statistics were also run on quantitative data generated from a STEM attitude survey, motivation survey, and standardized state-mandated content tests. Ultimately, researchers found that students entering the STREAM program were highly impacted by being given autonomy. For some, the transition was difficult and required teacher scaffolding. However, STREAM students outperformed or did not differ significantly from their peers on math, science, and language arts state standardized tests. This finding indicated the program was not detrimental to mastery of mandated content standards. This study addresses a concern in education: how to provide students freedom in their learning while keeping them deeply engaged and performing well on standardized tests.

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

3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

Examining the Assessment Practices of an Elementary Science Teacher
Jeni R. Davis, University of South Florida
ABSTRACT:
The purpose of this research was to examine an elementary teacher's practices to elicit student thinking during science class instruction. In a secondary analysis of a previous study, the present study focused on the broader question, what can we learn about the use of classroom assessments by examining the practices of an exemplary elementary teacher who utilized research suggested classroom assessments? While attending to superficial features of students' performances such as completion or correctness, it seemed as though the teacher's intent was much more on monitoring the students' performance instead of eliciting the students' ideas. This study raises the question if the assessment is less robust than in cases in which more substantive features such as content, depth, detail, and reasoning are dealt with.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

"It's a Gassy World": Using Middle School Students' Questions to Inform Climate Change Education
Asli Sezen-Barrie, Towson University, Maryland
Jenna H. Trevillian, Bates Middle School, Annapolis, MD
Elizabeth Hufnagel, University of Pittsburgh
ABSTRACT:
There is immense evidence showing that the climate system is warming and human behavior is linked to the change. Although there are various attempts to integrate climate change into school curricula, teachers have challenges in preparing and implementing climate change lessons. The aim of this study is to look at middle school students' wondering questions to understand how students experienced a climate change activity conceptually and emotionally. Then, informed by the participant teachers' suggestions, we aim to present ideas on how we can use students' wondering questions to support preservice and inservice teacher education. Designed as a multi-case explorative study, data comes from fourteen classrooms whose teachers implemented an activity they learned in a daylong workshop. A constant-comparative analysis of students' wondering questions (N=165) shows that the nature of the questions varies in three major categories: direct observation questions (conceptually problematic), next step questions (interdisciplinary connections, or extensive activity questions), and big idea questions (future projections, emotions, or solutions). We propose that these variations in their questions can be explained by students' emotional experience [perezhivanie]. The paper also makes suggestions for further teacher education programs, which might be in the interest to teacher educators and researcher in the NARST community.

Designing an Instrument to Measure Science Teachers' Appraisals and Emotional Responses when Facilitating Inquiry-based Instruction
Daniel M. Alston, The University of North Carolina, Charlotte
ABSTRACT:
Since the mid 1900's, authors of science reform documents have advocated for teachers to engage in inquiry-based instruction. However, most science teachers are not enacting teaching practices that align with what constitutes as proficient inquiry-based instruction. Currently The Framework for K-12 Science Education and the Next Generation Science Standards, ask teachers and students to engage in even more rigorous teaching and learning. Inquiry-based instruction is once again a useful strategy for accomplishing these expectations. Many science teachers are unfamiliar with how to facilitate this type of teaching and learning. This can result in teachers experiencing negative emotional episodes as they struggle to facilitate inquiry-based instruction. Unchecked, these emotional episodes have the potential to adversely alter teacher behavior which might subsequently undermine the goals stated in reform documents. Therefore, it is critical that teachers' emotions and how they manage their emotions be further researched. This study sought to design an instrument (TEACH-FIBI) that can assess how science teachers appraise and emotionally respond to challenging situations that can occur when facilitating inquiry-based lessons. In order to accomplish this goal, a two-phase initial instrument design and refinement process occurred. A discussion of the findings and future steps will be presented.

Exploring Fluctuating Interest in STEM Careers amongst Middle School Girls
Sheliza Ibrahim Khan, Western University
Isha Decoito, Western University
ABSTRACT:
This study is part of a larger STEM longitudinal project with a primary goal of understanding effectiveness of outreach programs in terms of demonstrating efficacy in particular contexts and populations. The objective of this paper is to explore students' pre-post STEM workshop career aspirations and determine changes in career interests over three years. Survey findings reveal that at the end of grade 8 overall student career interests in STEM fields demonstrated a generally negative trajectory, but when examining female and male interests separately, increases in interest were seen in some STEM fields. Specifically, increased interest among females resulted after the first phase but decreased after the second phase. The authors will discuss how these STEM outreach workshops

influenced career interests positively after grade 6 and 7, and possible influencers causing a decrease in interest in STEM careers after grade 8.

How Sentiments and Approaches Change from AP to Regular and to Honors Science Courses
Eugene Judson, Arizona State University
Lydia Ross, Arizona State University
ABSTRACT:
Eighty-five high school science teachers indicated how their approaches to teaching, their beliefs about learning, and the autonomy they have over a course varied between either an Advanced Placement (AP) and a regular science course or between an AP and an honors science course. Findings included the anticipated result that teachers spent a great deal more time having students prepare for tests in AP courses. Similarities between course types included strong sentiment that students should share their reasoning and relatively low emphasis on memorizing science vocabulary and facts. Significant differences included teachers having AP students complete homework more frequently, engage in more discussion, and analyze data more than regular-track students. Teachers were also more focused on honors students developing an interest in science and generally feel they have less control over content and goals in AP than in regular or honors courses. The gravity of these findings are placed in the context of the ongoing growth of AP STEM courses and the high value placed on the establishment of STEM AP courses by national organizations.

Improvement of Students' Science Knowledge and Socio-scientific Reasoning through Socio-scientific Issue Teaching
Hai T. Nguyen, University of Missouri, Columbia
Troy Sadler, University of Missouri
Andrew T. Kinslow, University of Missouri
ABSTRACT:
The purpose of this study was to identify evidence in students' socio-scientific reasoning improvement within the context of real-world socio-scientific issues (SSI). We used mixed methods research design to explore high school students' (n = 36) learning and reasoning. Results revealed that there was a significant improvement in students' socio-scientific reasoning (SSR) regarding complexity and inquiry before and after an SSI-based course. The teaching and learning activities in the SSI-based course were discussed as a potential source for the development of socio-scientific reasoning among participants. This study supports and extends other work related to how teachers' implication of SSI-based curriculum may influence students' SSR and has an impact on students learning scientific content knowledge.

Teaching Electrical Resistance to 6th Grade Visually Impaired Students
Betul Okcu, Ataturk University
Mustafa Sozbilir
Mustafa Bulbul
ABSTRACT:
This study aims to develop an instructional design teaching electrical resistance to 6th grade visually impaired students. Initially the needs of visual impairment students for particularly learning science were identified. An instructional setting was designed to meet their needs and it is evaluated. The study was conducted as a Design Based Research (DBR). The research groups are consisting of six visually impaired students including one blind at the needs analysis stage while the implementation of the developed instructional design was carried out with seven visually impaired students including one blind. The results showed a high achievement in gaining the intended learning outcomes regarding the concepts of electrical resistance. The results also indicated improvement in students' scientific process skills as well as developing positive attitude towards science.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

Disappearing trends: Examples of Simpson's Paradox in Introductory Science Courses
Rebecca L. Matz, Michigan State University
Zachary D. Nusbaum, Michigan State University
James T. Laverty, Kansas State University
Melanie M. Cooper, Michigan State University
ABSTRACT:
As calls for improvements in science education continue, it is important that researchers and practitioners be able to reliably characterize changes in instruction and assessment practices. We have developed two protocols for undergraduate introductory science courses, one for observation of classroom instruction and one for assessments. Using these protocols, we investigated the relationship between time spent lecturing and both student enrollment and how much high-stakes exams reflect the dimensions laid out in the Framework for K-12 Science Education. Scientific practices, crosscutting concepts, and core ideas form the foundation of the Framework and together are a vision for science education that emphasizes providing students opportunities to experience how science is practiced. Across biology, chemistry, and physics courses in aggregate, we find time spent lecturing is positively correlated with student enrollment and negatively correlated with proportion of exam questions that incorporate the dimensions. However, we

also find that these correlations either reverse or disappear when the data are disaggregated by discipline. These results demonstrate that classroom observation data should not be analyzed in aggregate, at least not without also considering analyses by discipline. By analyzing data only in aggregate, underlying disciplinary trends can go unnoticed, leading to potentially inaccurate interpretations.

What Attitudes Matter for Homework and Exams across First and Second Year Weeder Chemistry Courses?
Anita Schuchardt, University of Minnesota
Joseph J. Grabowski, University of Pittsburgh
Christian D. Schunn, University of Pittsburgh
ABSTRACT:
Students' performance in college chemistry has a broad impact on science majors that exceeds the number of students majoring in chemistry. Prior studies on performance have focused on students in introductory courses, when the material is largely review and students are still adjusting to college. It is unclear whether attitude factors identified for this population are stable at later time points in harder gatekeeper chemistry classes and which factors are predictive. This study identifies a set of five attitude factors that are stable across a large population of students at three time points in the college chemistry pathway. The predictive power on exam performance of these five factors is examined in combination with homework completion and prior performance for two different levels of college chemistry taught by the same instructor. Similarities and differences in outcome models are observed that are not simply correlated with similarities and differences in the means of predictors. For both courses, the predictors of the first exam outcome include students' homework completion and their belief that chemistry can be understood through an understanding of atomic and molecular interactions.

Exploring the Cognitive Processes and Scientific Epistemic Views Involved in Comprehending Multiple Representations in Physics Textbooks
Guo-Li Chiou, National Taiwan University of Science and Technology
Chin-Chung Tsai, National Taiwan University of Science and Technology
ABSTRACT:
The main purpose of this study was to explore the relationship between students' scientific epistemic beliefs and their visual behaviors while reading physics textbook. To achieve this purpose, we used an eye-tracking system, Mobile Eye, to record 40 college students' visual behaviors while reading a section of a physics textbook containing multiple visual representations. In addition, the scientific epistemic belief (SEB) survey was adopted to measure the participants' views on scientific knowledge. The preliminary results reveal that, the participants who obtained higher scores in the SEB survey tent to spend more time reading the explanatory text, but spent less time reading the descriptive text and the realistic picture. Moreover, the participants with more sophisticated SEB were more likely to make visual transitions between the realistic picture and the abstract diagram than those with less sophisticated SEB.

Reasoning and Arguments: An Exploratory Study of Community College Students' Theory Building and Argumentation Skills
Deborah Lan, The Ohio State University
Lin Ding, Ohio State University
ABSTRACT:
The purpose of this study was to explore student thinking in their reasoning abilities, understanding of the logical structure of arguments, and processes of creating theories and arguments. We investigated these three competencies by using written assessments. Correlations between variables in reasoning abilities and understandings of the logical structure of arguments were first analyzed followed by coding of patterns in creating theories and arguments. The sample for this study were undergraduates at a 2-year university. Findings include significant correlations between some of the variables for reasoning and understanding the logical structure of arguments as well as some emergent patterns in students' evidence and justification in theories and arguments.

Demonstration and Dialectical Arguments: Guiding Undergraduate Student Writing about Cancer Biology
Meena M. Balgopal, Colorado State University
Anne Marie Casper, Colorado State University
Paul J. Laybourn, Colorado State University
Ellen Brisch, Minnesota State University, Moorhead
ABSTRACT:
The value of writing-to-learn (WTL) activities is that they allow students to organize and manage facts from multiple sources. The question arises, though, "how much guidance do students need as they draw from multiple data sources to make sense of complex scientific topics?" The purpose of our study was to compare the rhetorical strategies used by students randomly selected from two sections of undergraduate cell biology that participated in WTL interventions about cancer treatments but received different levels of guidance. Students in the "lots of writing" section submitted "collections of thought" WTL assignments for the first three weeks, after which they engaged in peer evaluation activities and self-evaluation activities preceding each essay due date. Students in the writing-to-communicate section submitted three essays with no peer review. Forty-eight sets of essays (3 per student) were collected and classified using the Aristotelian dichotomy of demonstrations or dialectical arguments. The WTL assignments helped non-minority students form more dialectical arguments in their essays. However, minority students did not show a similar response. Although we are not surprised by the findings, we acknowledge that we need to probe deeper to better understand why minority students tend to write more demonstrative essays rather than dialectical essays.

The Impact of the Innovative Course on Developing Spatial Thinking Abilities in College Students
Youngjin Song, California State University, Long Beach
Lisa Martin-Hanses, California State University, Long Beach
Susan Gomez-Zwiep, California State University, Long Beach
Hye Sun You, Michigan State University
ABSTRACT:
The study describes the initial implementation and impact of an innovative course, An Introduction to Scientific and Spatial Reasoning (SCED 100) for first-year college students to promote spatial thinking abilities. The impact of the course was decided by individual students' spatial ability, measured by the Revised Purdue Spatial Visualization Test: Visualization of Rotations. The data was collected from 43 students who enrolled in two sections of the course. The results showed that the SCED 100 course has a positive impact on the improvement of students' spatial thinking abilities. First, the results of the Wilcoxon signed-rank test showed that there is significant difference between pre- and post- test scores ($z = 4.459$, $p < 0.001$). Second, when the students' entering levels of spatial thinking abilities were considered, the gains are much higher for the low group students. That is, students with lower spatial thinking abilities in the beginning have more benefit from the course than students with higher spatial thinking abilities. Third, the percent mean difference (9.67%) in item difficulty between pre (57.44%) and post (67.12%) was highly significant ($t(29) = 4.90$, $p < 0.001$). Contributions and implications for teaching, learning, and research are discussed.

Strand 6: Science Learning in Informal Contexts
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

Gender and Age Cohort Differences in Motivations, Participation Choices in Free Choice STEM-Learning Activities
Elysa N. Corin, Exploratorium
M. Gail Jones, North Carolina State University
Thomas Andre, Iowa State University
Gina Childers, University of North Georgia
ABSTRACT:
This study investigated gender and age cohort differences in the influential factors, motivations, and participation choices reported by American adults who engage in free choice STEM-learning activities. Data were collected through a national survey of adult STEM hobbyists in the United States; 2,838 complete surveys were collected. Results indicate that "helping others to learn" motivates older males to engage in free choice STEM activities to a greater extent than younger males. Men are also significantly more motivated than women to engage in free choice STEM-learning by "recognition from others". Women are found to be significantly more motivated by "environmental concerns" and more likely to participate in their hobby at outdoor recreation centers. "Having peers like me to interact with" is cited as significantly more motivating for the oldest cohort of male and female hobbyists when compared with a younger cohort. Observed differences in motivations and participation choices by age and gender may be influenced by differential constraints to participation. The results of this investigation highlight important considerations for supporting lifelong free choice STEM-learning and may be instructive in providing equal educational opportunities to distinct constituencies of learners, including women, or to support learning into older adulthood.

How Does Learners' Sociocultural Participation in their Communities Shape Their Ideas about Climate Change?
J. R. McGinnis, University of Maryland
Emily Hestness, University of Maryland
Natalie Harr Ylizarde, University of Maryland
Emily A. Freeland, University of Maryland
Wayne Breslyn, Montgomery County Public Schools
ABSTRACT:
The purpose of our investigation was to investigate learners' thinking about climate change, a critically important topic. We investigated the question: How does middle school learners' participation in the sociocultural activities of their varied communities inform the understandings of climate change? Climate Change is considered by many to be "a defining challenge of our time" (UN, 2014). However, not much is known of learners' participation in activities of their communities and their developing understanding of climate change. Rogoff's (2003) sociocultural perspective on learning guided our study. A sociocultural perspective directs our attention toward a consideration of how students' social interactions within the informal learning context may shape how they engage with and come to understand climate change. We conducted a qualitative case study. Our sample consisted of middle school learners in one USA MidAtlantic school. We collected data from three complementary methods (survey, drawings, and interviews). We report our participants' scientific understanding of climate change as well as the sources of their ideas from the activities (e.g., the media) the learners participate in their communities. We found potential linkages between learners' in-school and out-of-school communities and their ideas about climate change. Implications for curriculum, instruction, assessment and policy are discussed.

Middle School Girls' Science Achievement and Cognition, Effects of an After School Informal Science Program

Jennifer A. Gatz, Stony Brook University
Angela M. Kelly, Stony Brook University
Sheri L. Clark, Stony Brook University

ABSTRACT:
Middle school is a critical period in the cognitive and academic development of young women, and a time when their performance and interest in science may decline. This study was conducted to address how an informal science and physical activity intervention in previously sedentary middle school girls contributed to the improvement of executive functioning involved in science learning. Interdependent cognitive control processes may influence metacognition and exert a determinative influence on goal-directed pursuits. We applied this model to an after school program and measured its impact on students' cognition and science achievement. A 20-week informal nutritional science and triathlon training program served as the intervention for at-risk female middle school students. The comparison group of females was randomly drawn from middle school students of a similar demographic. Wilcoxon signed-rank tests were conducted on the intervention group for comparison of pre- and post-intervention scores. ANCOVA was used to determine the effect of the intervention on standardized measures of cognitive processes and science achievement. The intervention contributed to a statistically significant improvement in cognition and science achievement. These results suggest that an informal science program with a fitness component may produce improvement in the cognitive processes involved in science learning.

Reading Zoos: Using Discourse Analysis to Uncover Meaning in Zoo Signs

Benjamin L. Tupper, University of Michigan
Leah A. Bricker, University of Michigan

ABSTRACT:
This proposed poster explores language and other symbol systems used in zoo signage, and the role of these symbols to materially and symbolically construct nature and animals. The research questions that guided the preliminary analysis highlighted in this proposed poster were: (a) What patterns are found in the discourse of zoo signage, and (b) How does zoo signage position the human and the nonhuman? Data consists of 367 photographed signage across four exhibit areas at a local zoo. We drew on discourse analysis methodologies including genre analysis and social actor analysis to determine patterns and create a taxonomy of zoo signage in one exhibit area. Findings showed distinct genres were present, dominated by informative and explanatory signage. Signage showed a distinctive othering of the nonhuman and positioned the human actors as agents of power. Text and place-based messaging are important strategic tools for zoos but this preliminary work suggests that further research may be needed to explore the connection between discourse on zoo signage how zoos and other informal learning institutions position themselves and their educative mission.

Strand 7: Pre-service Science Teacher Education
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

Approaching Pre-Service Science Education Preparation with a Playful Learning Pedagogy

Jennifer L. Weible, Central Michigan University
Kevin D Cunningham, Central Michigan University

ABSTRACT:
With the increasing need for educators proficient in STEM fields, teacher education programs are struggling to implement programs that provide the needed content as well as experiences for pre-service teachers to work with youth using a variety of pedagogical strategies. To address this, we use a playful learning pedagogy within a teacher education program focused on supporting STEM education students academically, professionally, and socially. Students within a STEM Education scholars program were provided with opportunities in which a playful learning pedagogy was used for both training the scholars for upcoming outreach opportunities and for the scholars facilitating programs for youth (grades 4-6) in an after school STEM program. This data suggests that participation in the STEM Education workshops utilizing the playful learning pedagogy clarified the Scholars' desire to become teachers, gave them confidence in their ability to teach in a STEM field as well as in their ability to work with a broad range of students, and supported the formation of a learning community of like-minded peers. In addition, the facilitators found the students specifically developed teaching skills such as questioning techniques that helped engage the youth, and prompts that helped extend the youths' learning experiences during the STEM programs.

Developing a Three-dimensional View of Science Teaching: A Tool for Facilitating Preservice Teacher Learning

Corinne H. Lardy, California State University, East Bay
Michelle L. Sinapuelas, California State University, East Bay
Rachelle DiStefano, California State University, East Bay
Christine Bae-Lee, Virginia Commonwealth University
Michele Korb, California State University, East Bay
Danika LeDuc, California State University, East Bay

ABSTRACT:
The expanding adoption of NGSS and the Framework for K-12 Science Education on which they are based require not only significant shifts in the ways that inservice K-12 science teachers teach science, but also in the ways that teacher educators prepare

future science teachers. This presentation describes the initial development and testing of the ASET 3-Dimensional Learning Map (3D Map), a tool designed to be used in the context of a science methods course to support students' ability to critically reflect on and plan with the key components of three-dimensional science teaching. Initial development and testing of the tool was grounded in Improvement Science, and took place in three phases from Spring 2015 to Spring 2016. A variety of stakeholders provided input on the 3D Map, including inservice secondary science teachers, teacher leaders, NGSS coaches, and secondary science methods course instructors, and the tool was iteratively tested and revised in the context of two science methods courses. This presentation will describe how the content and use of the tool evolved over the course of the year, as well as the supports that were added to aid students to meaningfully apply the map as they learned to plan and teach science.

Designing Science Tasks for Productive Whole Class Discussions: Supporting Pre-service Teachers' in Task Selection and Design
Danielle K. Ross, Northern Arizona University
ABSTRACT:
This study focuses on three particular task types that, when used together, provide opportunities for students to participate and engage in all eight science and engineering practices described in the NGSS. These three task types are: (1) experimentation, (2) data representation, analysis, and interpretation, and (3) explanation. Experimentation tasks are tasks in which students engage in protocol design, critique, and/or follow a protocol to gather data. Data representation, analysis, and interpretation tasks involve students representing data and interpreting patterns. Finally, during explanation tasks, as the name implies, students provide explanations for patterns and phenomena. This study illustrates the need to support PSTs in developing their capacity for planning high-quality task-based discussion lessons. Teacher educators must provide more opportunities for the PSTs to plan, teach, and reflect on lessons of various types and at varying levels of authenticity. As the PSTs' ability to critically analyze and design this type of instruction develops, their lessons will become more aligned with the science disciplinary practices put forth by the NGSS.

Flexible Thinking: A Key Competency for Preservice STEM Teachers
Miri Barak, Technion, Technion-Israel Institute of Technology
Ariella Levenberg, Technion-Israel Institute of Technology
ABSTRACT:
Flexible thinking is viewed as a key competency for teaching and learning in an era of global and local changes; however, it has not yet been fully conceptualized or measured. Echoing this theoretical gap, the goal of this study was twofold. First, to generate a valid and reliable instrument for measuring flexible thinking in learning (FTL). Second, to examine the relationship between preservice teachers' self-reported FTL and their engagement in a new and unfamiliar instructional approach. This study describes the development of the FTL questionnaire. Content validity was assessed via eight experts in science education. Construct validity was assessed via exploratory and confirmatory factor analysis, by administering the questionnaire to preservice teachers (N = 429). Findings indicated three main factors that constitutes FTL: open-mindedness to others' ideas, adapting to new learning situations, and acceptance of new technologies. Findings confirmed the validity and reliability of the 19-items FTL questionnaire, indicating stability across populations and over time. In addition, findings indicated significant correlations between practical application of flexible thinking and preservice teachers' inclination to adopt new teaching and learning methods.

Strand 8: In-service Science Teacher Education
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

A Phenomenological Case Study of Pakistani Science Teachers' Experiences of Professional Development
Azhar M. Qureshi, Georgia State University, Atlanta
Kadir Demir, Georgia State University
ABSTRACT:
Effective teacher development is significant for any educational system to remain competitive in a global arena (Bayar, 2014). However, science teachers' professional development activities have often been found to be ineffective (Opfer & Pedder, 2011). This futility is more evident in developing countries like Pakistan. Science teachers also minimally participate in such activities due their ineffective experiences (Chval, Abell, Pareja, Musikul & Ritzka,2007). The purpose of this phenomenological case study was to study: how secondary school science teachers describe their experiences of professional development in Punjab (Pakistan); how they understood, made sense, and use of those intended goals of professional development opportunities and changed their practices as a result. The study was conducted in three districts of Pakistan by using purposive sampling approach. The qualitative data was collected from fifteen secondary school science teachers through semi-structured interviews (Seidman, 2013). The data were analyzed using three-stage coding methods, and thematic analysis. Three main themes emerged from data: sense making experiences, meaningful experiences, and contextual and cultural factors. The findings of the study communicate the significance of science teachers' voices, needs and active involvement in designing and implementation of professional development activities in developing countries.

Advancing Vector Knowledge and Confidence in K-12 Teachers
Greg Bartus, Stevens Institute of Technology

ABSTRACT:
Students demonstrate persistent confusion over the fundamental notions of vectors in introductory physics courses in college. Such student difficulties can be traced back to struggles that elementary and middle school teachers have with the basic subject matter. In order to improve in-service teacher content knowledge and confidence pertaining to vectors, we designed a unit on bridge truss analysis and embedded it into a college course designed for grades 3-8 teachers. This study investigated whether the course could improve teachers' confidence and understanding of vectors and whether there is a predictive relationship between those variables. We utilized two separate instruments for data collection: a diagnostic vector knowledge assessment instrument. First, paired-sample t tests for both the knowledge assessment ($p < .05$) and the confidence survey ($p < .001$) revealed statistically significant gains from pretest to posttest. Second, the regression model explained a significant ($p < .05$) amount of variance, 26%, in confidence in teaching vectors. The findings from this study support the idea that vector content knowledge and confidence can be developed by elementary and middle school teachers through an appropriately designed unit on bridge analysis with an emphasis on the content area and real world examples.

Bias against Elementary Teachers in a Local Professional Development Implementation
Samuel Severance, University of Colorado, Boulder
ABSTRACT:
Taking place in a large urban school district, this study examines the local implementation of a national professional development (PD) program designed to increase the capacity of teachers to provide science learning that embodies the vision put forth in the Next Generation Science Standards. This case study utilized an ethnographic approach, utilizing Cultural Historical Activity Theory in tandem with Mediated Discourse Analysis methodology, to discern how elementary teachers navigated the local implementation of a mixed-grade level PD enacted by district administrators and the tensions and contradictions they encountered in doing so. Rather than productively addressing a contradiction wherein elementary teachers are tasked with teaching science but are often positioned by others as not having the capacity to do so effectively, results of this study indicate the implementation of the PD by local facilitators actually led to actions that served to reinforce this contradiction, leading elementary practitioners to experience feelings of denigration within the PD.

Design, Implementation and Evaluation of a Graduate Course on Argumentation
Yasemin Ozdem-Yilmaz, Gaziosmanpasa University
Jale Cakiroglu, Middle East Technical University
Hamide Ertepinar, Istanbul Aydin University
ABSTRACT:
This study was a collaborative action research between teachers and researchers to design, implement and evaluate a graduate level argumentation course. The course was developed in the light of the argumentation research in science education and teachers' initial perceptions of argumentation, and improved through cycles of educational design research principles. In this paper, these processes as well as teachers' reflections on their learning were presented. In this study, we utilized a generic model of "Educational Design Research" (EDR) in three main core processes: analysis and exploration, design and construction, and evaluation and reflection. The study led to a main output, a graduate course on argumentation for teachers as an educational design model in addition to several contributions to argumentation theory in science education. Briefly, the analysis of data resulted with the following elements of the design solution: The knowledge of argumentation strategies and the pedagogical knowledge; the environment that would support reflection and feedback; the involvement of the participants in the planning of the learning activities; the plenty of opportunities to help participants have an experience in argumentation in various areas of science; the dynamic community of learners; and the teaching practices that provided occasions for action to test.

Effect of Professional Development Course on Palestinian Primary In-service Science Teachers' Attitude toward Teaching Sciences
Iyad M. Dkeidek, Al-Quds University, Al-Qasimi Academic College for Teachers
Ziad Qabaja, Al-Quds University
Mohsen Adas, Al-Quds University
ABSTRACT:
Attention to the attitudes of primary teachers toward teaching science is of fundamental importance to the professionalization of these teachers in the field of primary science education. 60 Palestinian in-service elementary science teachers were participated in a unique professional development course for one academic year. This professional development course is composed form 3 components, namely; face-to-face meetings, learning circles in the schools, and on-line training. During this study we investigated the effect of this unique professional development course on their attitude toward teaching sciences. It is found in this study that the participants in the current unique processional development course had improved primary science teachers attitude toward teaching science. More details provided inside.

Elementary Inservice Teacher Uptake of Reform-based Science Teaching Practices of a University STEM Professional Development Program
Madhura Kulkarni, Northern Kentucky University
Patricia S. Bills, Northern Kentucky University
Joseph Nolan, Northern Kentucky University

Morgan Carter, Northern Kentucky University

ABSTRACT:

Elementary teachers, as generalists, have few opportunities to incorporate new science teaching standards and the practices associated with them. And when they do have opportunities, they need support. We have re-designed a unique professional development program in which U.S. teachers participate 4 times a year in a live teaching demonstration and reflection session in their own classrooms with their own students (or the classrooms and students of colleagues in their same school districts). We have collected two years of quantitative and qualitative data on teachers' uptake of the ideas and practices presented in the year-long PD. Using surveys after each session (more than 800 total surveys per year), we have been able to summarize specific patterns of implementation among our participants. For both early elementary and later elementary grades, teachers reported statistically significant increases in their implementation of all eight PD-specific practices that we surveyed for. These data, and others we present, will contribute to the elementary science teacher education community by identifying areas worth researching in terms of how, when, and whether elementary teachers take up reform-based ideas in science teaching.

Evidenced-based Teacher Ownership of the Education through Science Philosophy and approach to Science Teaching at the Secondary Level

Ana Valdmann, University of Tartu
Miia Rannikmae, University of Tartu
Jack B. Holbrook, University of Tartu

ABSTRACT:

The study is related to a longitudinal study with its own philosophical ideas and approach to the teaching of science, based on the need to make science education more meaningful and relevant to students, to identify more strongly with the needs of society. It examines how 'lead' teachers can provide 'research-based' evidence of Teacher Ownership of the study intentions. The study involves 10 lead teachers who successfully acquired self-efficacy related to identified teacher needs, subsequently met during a 40 hours plus CPD. Data is gathered: from a pre-post Teacher Needs Questionnaire; Modules created by 'lead' teachers; Records of 'lead' teachers' meetings sharing best practices; Creation of classroom videos with comments on teaching effectiveness; Teacher/student records as portfolios; Semi-structured interviews. The data is analysed using a phenomenographic approach identifying 3 groups: emotional, experiential and paradigmatic. Emotional describes sense of ownership which utilize operational elements of the 3-stage model, but which is not interpreted as per the intended philosophy and approach. Experiential ownership describes the intended approach as per a socio-scientific introduction to scientific learning and applying the science in a society situation. Paradigmatic ownership describes full ownership of the philosophy and approach as per the 3-stage, EtS model.

Examining the Relationship between Professional Development and Classroom Practice in Elementary Science Professional Development

Judith Warren Little, University of California, Berkeley
Selena Burns, Heller Research Associates
Elena Duran Lopez, University of California, Berkeley
Joan I. Heller, Heller Research Associates
J. Owen Limbach, Heller Research Associates
Anna Weltman, University of California, Berkeley
Nicole Wong, Heller Research Associates

ABSTRACT:

The purpose of this interactive poster paper is to examine the relationship between teachers' professional development experience and subsequent classroom practice in a randomized controlled trial (RCT) study of elementary grades science professional development. The study demonstrated statistically significant positive outcomes for teacher knowledge and student learning outcomes among participants in the experimental conditions, by comparison with those in the control condition. The positive outcomes warrant efforts to investigate more fully whether and how the professional development experience manifests itself in classroom practice, and in what ways the classroom practice of experimental and control teachers varies. In this poster paper, we delve into the video records of the professional development experience and of teachers' subsequent classroom practice as a means of accounting more fully for the positive outcomes. This analysis has the potential to improve the explanatory power of a conceptual model of professional development effects and to inform practical efforts to identify and scale up promising professional development innovations and models.

Exploring Changes in Science Teachers' Conceptions and Connections of STEM Concepts and Earthquake Engineering

Baki Cavlazoglu, Karadeniz Technical University
Carol L. Stuessy, Texas A&M University

ABSTRACT:

Traditionally prepared secondary school science, technology, engineering and mathematics (STEM) teachers can benefit from professional development designed to increase their understanding about earthquake engineering and how engineering activities can integrate STEM topics to enhance students' learning. In a teacher professional development course focused on earthquake engineering, we used concept mapping to introduce participating teachers to how earthquake engineers apply knowledge from Social Systems, Designed Systems, Earth System, Physical Systems, and STEM Proficiencies. Our statistical comparisons of teachers'

individual and group concept maps before and after the professional development revealed significant increases in teachers' overall understanding of earthquake engineering as well as particular understandings about the use of earthquake engineering to integrate STEM knowledge. We discuss implications of this study to indicate changes in teachers' knowledge about complex engineering concepts and in their recognition of ways to integrate STEM in their teaching.

Exploring the Identity Development of a Beginning Inservice Elementary Science Teacher
Lisa Marco-Bujosa, Boston College
Abigail Jurist Levy, Education Development Center
ABSTRACT:
This poster draws upon the sociocultural theory of teacher identity (Gee, 2000) to shed light on the emerging identity of a beginning elementary science specialist. Findings are presented under three components of the sociocultural theory of identity—(a) affinity identity: the impact of relationships and science learning experiences; (b) discourse identity: embracing and enacting scientific inquiry; and (c) institution identity: the role of the school context. By examining the experiences of a new science specialist within a school environment that is extremely language intensive, we deepen our understanding of the challenges teachers face as they assume new roles and identities within their school. The findings are summarized in two main assertions for teacher identity development for science in at the elementary level. The findings of this study have implications for teacher preparation and in-service teacher education.

Factors Affecting Special Education Teachers' Burnout and Perceptions of Mindfulness- Practices to Build Social/Emotional Competence
Carol Cao, Texas Tech University
ABSTRACT:
This convergent parallel mixed methods study addressed the challenges special education (SpEd) teachers of students with learning disabilities (LD) face, the supports SpEd teachers need to help with feelings of burnout, and SpEd teachers' perspectives about the benefits of mindfulness-based practices to help with burnout and social and emotional competence (SEC). Results from the Maslach Burnout Inventory-Educator Survey noted that emotional exhaustion was the burnout dimension that contributed most to burnout. Semi-structured interviews and observations established the factors leading to burnout, the supports in place and the supports needed to help alleviate feelings of burnout, and the benefits and challenges of mindfulness-based practices. Mixed-methods results confirmed that the factors leading to burnout affect emotional exhaustion more than personal accomplishment or depersonalization. In addition, mindfulness-based practices were discussed as one method to help teachers reduce feelings of burnout and increase SEC.

FOCCUSS and NEVADA-S: The Results Two Years of Statewide NGSS Professional Development
David B. Vallett, University of Nevada, Las Vegas
Hasan Deniz, University of Nevada
Kristoffer Carroll, Southern Nevada Regional Professional Development Program
Bret Sibley, Southern Nevada Regional Professional Development Program
Eileen M. Gilligan, Clark County School District
ABSTRACT:
This study examined the results of two consecutive years of statewide PD on science teacher self-efficacy and content knowledge, along with qualitative examination of student learning through submitted artifacts. The PD model consisted of extensive blended-learning summer institutes with content delivered by university faculty experts in those topics and pedagogical instruction in inquiry models (POE and a modified Science Writing Heuristic), followed by teacher development of lessons and materials aligned to the NGSS and vetted by self-reflection and their peers through EQUIP rubric analysis of the lessons and video of the lessons being taught.

Strand 10: Curriculum, Evaluation, and Assessment
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

A Molecular Genetics Learning Progression Web: Using Model Search to Target Hub Ideas
Josefina Correa, University of Puerto Rico, Rio Piedras
Amber Todd, Wright State University
William L. Romine, Wright State University
ABSTRACT:
American education policy emphasizes the importance of understanding of genetics. While work toward developing assessments of students' understandings of genetics (i.e. Abraham et al., 2014; Author, 2016) and understanding college students' ideas and misconceptions about genetics (i.e. Daack-Hirsch et al., 2012; Knight & Smith., 2010) has been extensive, there has been a dearth of literature describing how college students' ideas change in response to traditional introductory biology instruction. In this paper, we used Version 2 of the Learning Progression-based Assessment of Modern Genetics (LPA-MG) to analyze test scores from 122 students (40 biology majors, 82 non-biology majors) from a Midwestern open-enrollment research university, prior and after lecturing

the students in a Genetics course intended for majors, which included topics in Genetics and Molecular Biology. A causal model relating the progression of the concepts was generated with these scores using TETRAD's Fast Greedy Search algorithm. A change in the distribution of the hub ideas, concepts with a degree greater than two, was observed. We propose the implementation of model search for assisting curriculum development, as it details the progression of ideas throughout the learning process.

Assessment of Next Generation of Science Learning
Andrew J. Womack, University of Missouri
Eric P. Wulff, University of Missouri
Troy Sadler, University of Missouri
William L. Romine, Wright State University
ABSTRACT:
In today's US educational environment, the Next Generation of Science Standards (NGSS) are quickly being adopted into more and more states. The NGSS explicitly emphasizes an interaction of content knowledge and science and engineering practices. The need for assessing next generation science learning (NGSL) of this interaction is being recognized by researchers and teachers. We have created a prompt and a rubric to elicit and assess NGSL specific to water systems content and the interaction with argumentation related practices of NGSS. This instrument framework however can be implemented to assess nearly all NGSS content and its interaction with the NGSS argumentation practices. In this paper we describe the generation of the prompt and rubric and the reason for inclusion of the various elements of each. We also discuss the findings of high user reliability and the results of a pilot study using the instruments. We then describe its contribution to the scientific research community as a whole as well as teachers teaching in NGSS classrooms.

Comparing the Alignment between Two Observational Measures of Science Teachers' Instructional Practice
Jamie N. Mikeska, ETS
Joshua M. Rosenberg, Michigan State University
ABSTRACT:
Teacher evaluation systems are currently used for two main purposes: (1) to support school district leaders in making promotion, retention, and hiring decisions for K-12 teachers and (2) to provide formative feedback to these teachers in order to improve their instructional practice. While scholars have explored the reliability and validity properties of observational measures used as part of teacher evaluation systems, prior research has not taken into account how differences in the actual observation protocols used may impact the conclusions drawn about the quality of teachers' instructional practices. To address this gap, this study examines the alignment between two science-specific observational measures of teaching quality -- the Quality Science Teaching – Measures for Effective Teaching (QST-MET) protocol and the Inquiring into Science Instruction Observation Protocol (ISIOP) – in the context of secondary biology teachers' instruction. Findings showed small to modest relationships between scores from these two observational measures, leading to wide discrepancies in how teachers would be evaluated in terms of their instructional quality. These findings suggest the importance of carefully considering the specific observational measures used when making consequential decisions and providing formative feedback to teachers.

Engineering and Science: Striving to Understand their Interrelated Roles in the Curriculum
Eunjeong Kim, University of Georgia
J. Steve Oliver, University of Georgia
ABSTRACT:
The Next Generation Science Standards (NGSS) have emphasized the importance of integrated learning of science, technology, mathematics, and engineering in science education. These new standards have created a more complex vision of the science curriculum. Research suggests that many teachers feel that they are unprepared to implement aspects of this vision, especially engineering design. In this proposal, the history of engineering education and its points of intersection with science teaching are explored. These points of intersection show that engineering has been at various times taught as a practical application while at other times emphasis has been placed more on its scientific base knowledge. The inclusion of engineering into the science curriculum will require both practical applications and connection to the science knowledge. Research suggests that practical applications which are explored through engineering design are an effective means to support students in learning the conceptual knowledge of science. In particular, research has shown that the use of practical problems is particularly conducive in the instruction of students who are traditionally low achieving as well as students of ethnic minority groups and those who are female.

Making Science Texts Accessible to Middle Grade Students with Learning Differences
Regina Suriel, Valdosta State University
Crystal Randolph, Valdosta State University
ABSTRACT:
Written science texts are important sources for the development of scientific literacy. However, students diagnosed with learning disabilities, cognitive impairments, or speech/language impairments and English language learners (ELLs), collectively referred to as students with learning differences (SLD), often experience difficulties with language and literacy skills that impede access to science texts. When provided with text enhancements, such as decreased syntax complexity, on par grade readability levels, utilization of morphemes and video-visuals, the complex language of science texts become more accessible. The researchers of this study developed

a life science ecology unit using text enhancements to examine academic gains in seventh-grade students, SLD in particular, as the result of their use of the ecology unit. The ecology unit was used as the sole source for review of ecology concepts in three seventh-grade classrooms. Qualitative data and pre/posttest score gains support the use of text enhancements with SLD. Findings of this study further our understanding of how science text enhancements scaffold learning and supports metacognition.

Measure of Affect in Science and Technology (MAST): Development and Validation of a New Instrument
Eric P. Wulff, University of Missouri
William L. Romine, Wright State University
Troy Sadler, University of Missouri
ABSTRACT:
Affect represents a broad set of ideas that subsumes several psychological constructs including interest and attitude, which have both been shown to be significant for science learning. The purpose of this study was to create and pilot the Measure of Affect in Science and Technology (MAST), a new measure of interest in and attitudes toward science and technology specifically designed for middle school students. The MAST was administered to 138 students from five classrooms, including 92 6th graders and 46 7th graders at a middle school in a Midwestern town. Exploratory factor analysis suggests a single main dimension which explains 35% of the variation in the data and four additional dimensions which account for an extra 35% of variation. We found that male students demonstrated statistically significantly higher measures on the MAST than females students ($F1,133 = 4.94$, $p = 0.028$, $\eta 2partial = 0.036$, $d = 0.56$). Our results suggest that the MAST can be effective for distinguishing the difference between personal and situational interest and that it offers a valid, reliable, and educationally useful instrument for assessing middle school student affect.

Measuring Students' Climate Change Knowledge: Instrument Development and Validation
Andrea Drewes, University of Delaware
Wayne Breslyn, Montgomery County Public Schools
J. R. McGinnis, University of Maryland
Chrystalla Mouza, University of Delaware
Emily Hestness, University of Maryland, College Park
Joseph Henderson, University of Delaware
ABSTRACT:
The purpose of this work was to design an assessment that measures climate change related content knowledge and to explore the validity and reliability of the measure with middle school students. Climate change has steadily become more relevant for students and teachers due to its inclusion in NGSS. Yet this is a science topic that is complex and challenging topic to learn and teach as alternative conceptions abound. Currently there is no instrument available to measure climate change knowledge that is both appropriate for middle and high school students and has been empirically established as reliable. This proposal aims to share the development process for the Climate Change Assessment and to examine it through psychometric analysis using classical test statistics.

Sci-Lift Participants' Initial Ideas about Educative Curricular Materials
Julie A. Birt, University of Missouri
Sarah A. Arnold, University of Missouri
Mojtaba Khajeloo, University of Missouri
Marcelle Siegel, University of Missouri, Columbia
ABSTRACT:
To support teachers' effective use of educative curriculum, it is vital to understand how teachers critique and modify new curriculum materials. Educative curriculum is unique in that it provides support for not only student but also teacher learning. The purpose of this study is to understand how future SciLift professional development participants understand and analyze science curricula. Four participants were given an educative and a traditional curriculum focused on genetically modified organisms to compare and contrast in an online-based open-ended survey form. The students were prompted to consider the seven criteria of effective, reform-based curriculum analysis defined by Beyer and Davis (2012). These same criteria were used as a framework to determine the strengths and weaknesses found in the curriculum understandings of the participants. Weaknesses were found primarily in three key areas: the conceptualization of assessment in educative curricula, providing teachers with clearer discussion questions to help them promote inquiry activities, and accessibility to all students. Our findings suggest that it is important to focus future professional development on teachers' understandings of assessment, inquiry and accessibility rather than on learning goals and purposes.

From Fragments to Wholes: Investigating the NOS in the Science Curriculum in Taiwan
Yi-Fen Yeh, National Taiwan Normal University
Sibel Erduran, University of Oxford, UK
Ying-Shao Hsu, National Taiwan Normal University
ABSTRACT:
The inclusion of Nature of Science (NOS) in science curriculum has been advocated around the world for several decades. However, the precise definition of NOS has been equally debated for some time. The discussion on characterizing NOS has recently gained momentum. One approach that has advocated a holistic approach to NOS is referred to as the Family Resemblance Approach (FRA) (Irzik & Nola, 2014). The key components of the FRA include the aims and values of science, methods and methodological rules,

scientific practices, scientific knowledge as well as the social dimensions of science including the social ethos, certification and power relations. In this paper, we use an adaptation of the FRA approach by Erduran & Dagher (2014a) to analyze how NOS is framed in the middle school science curriculum in Taiwan. The framework is relevant for our purposes because we aim to gain understanding of a broad range of aspects of NOS (i.e., aims, methods, knowledge, social context of science) in the Taiwanese science curricula and the FRA approach is inclusive of such a broad characterization.

Strand 11: Cultural, Social, and Gender Issues
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

African American Students' Perceptions of Science Education: What They Really Think
Tara M. Nkrumah, University of South Florida
Selene Y. Willis, University of South Florida
ABSTRACT:
Burgeoning K-12 academic assessments reveal variable skill levels with particularly low results among minority groups (NAEP, 2015; Ladson-Billings, 2006; Jalomo Jr, R., 2000). In National Assessment of Educational Progress (NAEP) and SAT results, the historical evidence of student academic achievement trends reveal white students outperform African Americans (Lee, 2002). The reported academic disparity between minority and white students stimulates dialogue on how to close the achievement gap. Strickland and Alvermann (2004) posit, "despite efforts by educators and policymakers during the past several decades, achievement gaps between certain groups of students stubbornly persist" (p.6). Science education scholars have credited multiple sources for the achievement gap, from macro level related issues of race, class and economics to micro level issues of teacher pedagogy (Norman et al., 2001). Existing studies report achievement gaps between white and non-white students, however, little is known about the experiences of the students who fail to meet this standard level of achievement. This descriptive case study explores the experiences of two African American students using the theoretical framework of Gloria Ladson-Billings, Cultural Relevant Pedagogy (CRP) and Paulo Freire's Critical Pedagogy (CP) collectively to illuminate and address how students' of color self-development is constructed in science education classes.

Decolonizing Science Education Research: Dismantling Academic Power Structures in Solidarity with the Subaltern
Jean R. Aguilar-Valdez, Portland State University
ABSTRACT:
Decolonization involves dismantling colonialist epistemologies that frame dominant peoples and cultures as more legitimate and authoritative over others. This study focuses on decolonizing educational research methodologies within science education by deconstructing the typical, positivistic researcher/researched relationship, which is rife with power relations over those “researched,” and dehumanizes participants by rendering them objects to be studied. Decolonization of research methodologies entails working in solidarity with participants towards a common liberation and not researching on participants for the benefit of the dominant. A multi-year-long research endeavor with Latin@ undocumented high school science students is presented as an example of utilizing a decolonizing approach: working in solidarity with research participants, as mutual agents for social change.

Developing Pre-service Teachers' Knowledge for teaching Science to English Language Learners through Merging Learning Cycle and SIOP Models.
Vanashri J. Nargund-Joshi, New Jersey City University
ABSTRACT:
There are increasing number of English Language Learners and few teachers specially trained to work with them, especially in sciences. This study aims to develop preservice teachers’ pedagogical content knowledge (PCK), which is defined as the knowledge developed by teachers to help others learn specific content. A state-led effort of Next Generation Science Standards promotes science and engineering practices at all grade levels and for ALL students in the United States. This research project will challenge PSTs views and possible misconceptions about teaching in ELL classrooms via structured reflections and will support their learning through different activities that build their repertoire to address the needs of ELL. This qualitative research study will generate case studies allowing me to compare PSTs’ PCK development to teach science to ELL. It will also allow me to develop in-depth understanding of reasons behind similarities and differences in teachers’ PCK development for teaching science to ELL.

The Role of Failure in the Development of STEM Professionals
Adam V. Maltese, Indiana University
Amber Simpson, Indiana University
ABSTRACT:
Need to complete

Strand 12: Educational Technology
Poster Session A

3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

Digital Badges and Informal Science Learning: Badges for College Credit
Theresa Horstman, University of Washington Bothell
Gavin Tierney, University of Washington
Carrie T. Tzou, University of Washington Bothell
ABSTRACT:
Digital badges have been used in educational contexts, both formal and informal settings. Efforts to incorporate digital badges and other forms of micro-credentials have increased espeically with the support of Mozilla OpenBadges (http://openbadges.org/) and Digital Media and Learning (DML) Competitions. In addition to increasing participant engagement digital badge systems also have to support the unique objectives and goals specific educational programs in both informal and formal settings. Measuring how much of an impact digital badges can have on student learning remains elusive and uncertain. We argue there needs to be an analysis of the badge criteria and the badge system itself, in addition to analysis of participant and platform analytics. In this study we analyze data collected from design documentation, platform and badge analytics, program developer and participant interviews, participant surveys and video of participant participation in the programs to better understand in what ways do digital badges impact youth science learning, identity, and equity. Early analysis indicates badges impact how learners participate in the program. Badge attributes such as frequency in which participants receive them, the sequencing of the badges, and progression of badge distribution impacts youth's choice and agency within the program.

Entrepreneurial Thinking: Cross Cutting Concepts for Science Teachers
Len Annetta, East Carolina University
Marina Shapiro, George Mason University
Richard Lamb, University at Buffalo
ABSTRACT:
This paper describes the importance of entrepreneurship education across various grade levels ranging from elementary school to higher education. The study was done with graduate level students enrolled in a technology focused science education course at a Mid-Atlantic university in the United States. A nonrandomized, pretest-posttest, within comparison group design. was employed to investigate effects on student self-efficacy toward technology integration and entrepreneurship in software development and lean business start up. Results suggest statistically significance gains in both areas.

Inquiry-Based Ecosystem Science Learning in Virtual Environments - Comparing Virtual and Physical Concept Mapping
Shari Jackson Metcalf, Harvard University
Amy M. Kamarainen, Harvard University
Jeffrey King, Harvard University
Tina Grotzer, Harvard University
Chris Dede, Harvard University
ABSTRACT:
EcoMUVE is a middle school science curriculum in which students explore an immersive virtual ecosystem and learn its causal dynamics through collaborative inquiry activities. Students work in teams of four to construct hypotheses about the relationships in the virtual ecosystem, and construct concept maps as representations of their conceptual understanding of the causal relationships in the ecosystem. We compare students of one teacher who constructed concept maps on paper, with students of another teacher who constructed concept maps using a computer-based concept map tool. Students using the computer-based tool included more nodes and connections, and differences were also observed in the specific selections and categories of nodes used in the two treatments. The findings provide insight into the impact of concept map scaffolding choices, and inform the design of future versions of the tool.

Learning Chemistry Concepts through Serious Game Play
Marina Shapiro, George Mason University
Len Annetta, East Carolina University
ABSTRACT:
The attraction of games for learning continues to be on the rise. Research shows that well designed serious educational games have been shown to increase learning and performance in science classes. The implementation of game-based learning into a General Chemistry course was examined. Findings will be presented from a quasi-experimental comparative design intervention study that was conducted with undergraduate college students in a General Chemistry course to improve students' learning of chemistry concepts and scores on summative assessments. Results of the study showed that the experimental group who played the chemistry video game yielded significantly higher scores on summative assessments than the comparative group which utilized traditional lecture teaching methods. Implications for implementation of serious educational games into the chemistry classroom will be discussed for supporting teaching practices for professors of general chemistry courses.

Teaching the Systems Aspects of Epistemologically Authentic Experimentation in Ecosystems through Immersive Virtual Worlds
Tina Grotzer, Harvard University

Shari Jackson Metcalf, Harvard University
Michael S. Tutwiler, Harvard
Amy M. Kamarainen, Harvard
Meredith Thompson, MIT
Chris Dede, Harvard University

ABSTRACT:
Helping students to learn epistemologically authentic forms of experimentation is an important goal for ecosystems science education. Ecosystem scientists have developed forms of experimentation that offer insight into the behavior of systems dynamics and that honor the systems nature of the concepts. These forms of experimentation and the broader assumptions that surround them represent shifts in thinking about the nature of systems and of experimentation. However, teaching them in the classroom in ways that do not reduce their systematic aspects is difficult, particularly in that these systems dynamics play out over expansive spatial and extended temporal scales that students typically struggle with. Immersive virtual learning environments may play a role in enhancing the presence of these concepts in the classroom. EcoXPT is an inquiry-oriented middle school curriculum designed to leverage the forms of epistemologically authentic experimentation that ecosystems scientists engage in towards teaching students about the complex causal dynamics of ecological systems and how scientists come to understand them. This paper presents the theoretical importance of the forms of experimentation that EcoXPT offers and considers both the affordances and limitations of doing so in an immersive, computer-simulated world. It shares pilot data demonstrating the feasibility of the endeavor.

The Characteristics of Inquiry-type Science Teachers using the Scratch Program for Movements of the Planets

Seoung-Hey Paik, Korea National University of Education
Youngjun Lee, Korea National University of Education
Eun Sun Choi, Korea National University of Education
Jeong Won Choi, Korea National University of Education

ABSTRACT:
Despite the importance of the scientific inquiry process in science learning, teachers lack knowledge regarding appropriate teaching tools for scientific inquiry. Therefore, a new teacher education program is required to help teachers improve their science-inquiry teaching. This study investigated the effects of technology education as an inquiry teaching tool and proposed a future direction for teacher education programs. The 37 teacher participants were educated in the use of the Scratch program and used it to develop teaching models for geocentric and heliocentric theories. The data obtained from the Scratch results, teachers' presentation materials, and questionnaire responses were analyzed and classified, and teachers' thoughts on scientific inquiry were divided into two types: knowledge-centered inquiry and active inquiry. The teachers classified as "knowledge-centered inquiry" continued to simply confirm theories despite using the Scratch tool, due to the influence of their past education. Teachers classified as "active inquiry" formulated scientific theories and engaged in significantly meaningful "learning through prediction" using the Scratch model; this gave these teachers a sensibility of the science aesthetic. The results provide guidelines for future teacher training programs that develop professional knowledge of inquiry classes using technology that requires sufficient learning time to create instructional materials.

Strand 13: History, Philosophy, and Sociology of Science
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

Developing Third Graders' Conceptions of Nature of Science and Scientific Identities through a Gravity Unit

Valarie L. Akerson, Indiana University
Naime Elcan, Indiana University
Banu Avsar Erumit, Indiana University

ABSTRACT:
Third graders in this at-risk school participated in a study that explored their developing conceptions of nature of science (NOS) along with their developing NOS identities through a unit on gravity. This 8 week gravity unit emphasized NOS aspects as well as science content knowledge in terms of forces—rotational force, push and pulls, and gravity. Students NOS conceptions were measured through interviews using the VNOS-D. Development of student NOS identities was explored through videotapes of instruction, including interactions between teacher and student and students with other students during investigations, and collection of student work along with videotapes of their presentations. It was found that third graders did develop content knowledge with regard to gravity and forces, as well as knowledge about NOS. They began to see themselves as “knowers of NOS” as the unit proceeded.

Using Educative Curriculum materials to Support Integration of Engineering Design in Science and Technology Classrooms

Jonathan Singer, University of Maryland, Baltimore
Tory Williams, University of Maryland, Baltimore
Julie Ross, University of Maryland, Baltimore
Christopher Rakes, University of Maryland, Baltimore
Jacqueline Krikorian, University of Maryland, Baltimore

ABSTRACT:

The present study explored the benefits and limitations of an educative curriculum-based PD system as a mechanism for strengthening teacher pedagogical skills for integrating engineering practices in high school biology and technology education classrooms. 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 and engineering design instruction. Changes in teacher pedagogical practices were measured using the Reformed Teaching Observation Protocol (RTOP) at three distinct time points. The first time point occurred prior to the start of the PD intervention and served as a "baseline" measure. Two additional data points were collected as the teachers enacted the educative curriculum. The educative curriculum-materials and PD provided a mechanism for teachers to transform their teaching to meet the NGSS challenges. Year 1 results indicated that teachers had begun to transform their teaching and pointed to particular lessons within the curriculum that most facilitated the reform.

Strand 14: Environmental Education
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

Children's Sense of Place in New Town through Migration Policy in Korea
Seoung-Hey Paik, Korea National University of Education
Eunjeong Ju, Mirue Elementary School
Choi Hee, Chungcheongbuk
Jang Sujeong, Korea National University of Education
ABSTRACT:
In recent years, there has been a massive movement of the Korean population due to the relocation of the de facto administrative capital from Seoul to Sejong City. The purpose of the study was to determine the effect of mass migration on the formation of children's sense of place, and to find a way to facilitate said formation. Participants in this study were 117 third-graders and 113 sixth-graders in Chetmaul, a village of Sejong City. They were presented questionnaire comprised three categories (place cognition, place attachment, and place practice) to examine the children's sense of place and open-ended categories to examine elements of both topophilia and topophobia. As the result, the children's sense of place in Sejong City was not showed significant difference with other city. In a comparison of children's sense of place according to grade, the third-graders scored significantly higher than the sixth-graders ($t = -5.134$, $p < .01$). Specifically, the place attachment and place practice of third-graders were significantly higher than those of sixth-graders. The analysis of topophilia and topophobia was showed that the range of the sixth-graders' sense of place was more narrow than that of the third-graders but their experiences were active and independent.

Dirt, Bugs, and Worms: Attitudes and Self-efficacy of Educators Regarding Dirty and Scary Science
Nichole L. Nageotte, Indiana University
Gayle A. Buck, Indiana University
ABSTRACT:
The purpose of this study was to examine the self-efficacy of teachers regarding topics with the potential to elicit disgust or fear responses. During an outdoor soil ecosystem activity, thirty-three teachers were observed for behavioral and verbal responses to the soil ecosystem and the invertebrates encountered. In addition to observations, teachers completed a semantic differential attitude scale (SDAS) regarding the soil and invertebrates. Their self-efficacy in teaching about soil and invertebrates was determined using a modified Environmental Education Efficacy Belief Instrument (EEEBI). Correlations were calculated to compare the means from the EEEBI and the SDAS. Throughout the activity, there were nineteen reactions classified as positive or negative. Out of these, 63% were considered negative and 37% were considered positive. The results of the correlations suggest that teachers with positive attitudes towards invertebrates were more likely to have a higher self-efficacy in teaching about these organisms and the soil ecosystem than those with negative attitudes. The teachers with high self-efficacy and positive attitudes towards invertebrates would also be more likely to use the soil activity in their own classrooms.

Discourse on Water in Society: An Analysis of Introductory Geography Textbooks
Francesca A. White, Indiana University
ABSTRACT:
Historically, textbooks have positioned as sites of authoritative knowledge in undergraduate science classrooms. As such, this authority often goes unquestioned and thus potentially positions knowledge about controversial topics, such as water in society, as neutral. This paper presents an exploratory analysis of five introductory geography textbooks. Using discourse analysis, I considered how the interactions between water and society was framed, specifically focusing on the ways in which students may first be introduced to key debates and socioscientific issues related to the environment. This work provides a basis for future studies politically charged topics in undergraduate courses and advocates critical scientific literacy in undergraduate science and environmental education. Key words: critical scientific literacy, socioscientific issues, discourse analysis, undergraduate

Exploring History for Place-based Learning of Sustainability
Miyoun Lim, Ewha Womans University

ABSTRACT:
It explores how children experience and make sense of sustainable architecture as they participate in a field based environmental education program which takes place at a historic palace, Changdeokgung in Korea. Interested in exploring pedagogical potential of historicity in place based education, we examined how historicity can support and facilitate sense making of sustainable architecture. It discusses pedagogical potential that a historic place affords as it supports and facilitates 1) contextualization, 2) situated inquiry, and 3) reflection on one's own relationship with nature. This authentic, situative, and practiced nature of historicity could serve as a rich learning context for place based education. With this study, we wish to bring educators' and researchers' attention to further inquiry on historical dimension of place.

Indonesian Pre-service Biology Teachers' Perceptions towards Environment and Field Trips as an Environmental Education Tool
Minsu Ha, Kangwon National University, South Korea
Arif Rachmatullah, Kangwon National University, South Korea
Fenny Roshayanti, University of PGRI Semarang, Indonesia
ABSTRACT:
Pro-environmentalism is already observed by most people who are involved in natural sciences, including pre-service biology teachers, whom are one of the most important tools that could change the world through education. It has been known that social aspects can affect one's attitude towards the environment, and Indonesia has been known as a country which has unique social values. This study aims to explore Indonesian pre-service biology teachers' perceptions towards the environment and field trips as an environmental educational tool. We studied 147 Indonesian pre-service biology teachers (10% male and 90% female) enrolled in two universities in Indonesia. We employed five variables (Human Utilization, Ecocentric Concern, Field Trips Perception, Intention to Act and Environmental Movement Activism) from two different instruments. We used the Pearson Correlation test and Partial Correlation test to analyze our data, and found that all of the variables are highly ($p<0.01$) correlated to one another. Perception of Field Trips for Environmental Education and Ecocentric Concern were the mediating factors for the three other variables. From our finding, we conclude that better environmental education, especially for outdoor activities, is needed for Indonesian pre-service biology teachers in order to have a greater impact on Indonesian natural conservation.

Interpreting Middle School Students' Climate Change Learning through a Figured Worlds Perspective
Emily Hestness, University of Maryland, College Park
J. R. McGinnis, University of Maryland
ABSTRACT:
This qualitative case study examined climate change learning among 6th grade students in one middle school on the U.S. East Coast. We applied a figured worlds theoretical perspective (Holland, Lachicotte, Skinner, & Cain, 1998) to frame climate change learning as a process of identity and agency formation in relation to climate change. We examined how students' conditions (or sociocultural context) appeared to shape their climate change learning, and conversely, how students' climate change learning had the potential to reshape (or reinforce) their conditions. Data collected included drawings, assessments, individual and focus group interviews, and classroom observations. We interpreted three key means by which participants' interactions with/(in) their conditions appeared to inform their figured worlds of climate change. These included: 1) attending to information communicated by others, 2) observing human behavior (perceived as) relevant to climate change, and 3) observing changes in the natural world (perceived as) evidence of climate change. We posited that participants' climate change identity and agency were likely informed by conditionally-mediated values and knowledge. How or whether participants ultimately enact these roles in their in-school and out-of-school lives is yet unknown, and – we posit – subject to change as they evolve in their self-understandings in relation to climate change.

Strand 15: Policy
Poster Session A
3:15-4:15pm, Hyatt Texas Ballroom A, B, and C

An Analysis of Research on the Impact of Block Scheduling on Science Teaching and Learning
Dorothy Holley, Clayton High School
Soonhye Park, North Carolina State University
ABSTRACT:
The purpose of this study was to provide a comprehensive review of the literature surrounding block scheduling to better understand what the last twenty years of research tells us about the impact of block scheduling on science teaching and learning. Forty four selected articles were examined for arguments or reasoning as supporting block scheduling, opposing block scheduling, or stating that block scheduling did not make a difference in the argument. Five categories emerged: 1) organizational issues, 2) curricular issues, 3) instructional issues, 4) learning outcomes, and 5) disciplinary issues. The arguments/reasons were further analyzed into 23 sub categories, with the number of studies that make each argument recorded. Data from 30 studies supported block scheduling, data from 29 studies opposed block scheduling and data from 16 studies stated that block scheduling did not make a difference for that argument. Issues associated with block scheduling included school funding, presumed science benefits, teacher retention and student learning outcomes.

Poster Session B
4:15pm – 5:15pm, Hyatt Texas Ballroom A, B, and C

Strand 1: Science Learning, Understanding and Conceptual Change
Poster Session B
4:15pm – 5:15pm, Hyatt Texas Ballroom A, B, and C

Deepening High School Students' Knowledge about Earth Science Topics Through Scientific Evaluation and Plausibility Reappraisal
Janelle M. Bailey, Temple University
Doug Lombardi, Temple University
Elliot S. Bickel, Temple University
Shondricka Burrell, Temple University
ABSTRACT:
Critical evaluation is an important aspect of science and is receiving increasing attention in science education. The present study investigated (1) changes to plausibility judgments and knowledge as a result of a series of instructional activities that facilitated evaluation of scientific and alternative models in four different Earth science topics (climate change, fracking and earthquakes, wetlands and land use, and the formation of Earth's Moon) and (2) whether evaluations promoted by the activities mediate the relation between post instructional plausibility and knowledge. Repeated measure MANOVAs showed that participants shifted toward scientifically accepted explanations and increased their knowledge about relevant Earth science topics after participating in the activities. Greater levels of evaluation mediated the plausibility shifts and knowledge increases, as shown by structural equation modeling. Effect sizes were small to large, depending upon topic and instructional context. The activities used in this study can help students develop their critical thinking skills by facilitating evaluation of the validity of explanations based on evidence, a scientific practice that is key to understanding both scientific content and science as a process.

Development and Validation of a Learning Progression for Systems Thinking in Ecosystems
Hui Jin, Educational Testing Service
Hyo Jeong Shin, Educational Testing Service
Hayat Hokayem, Texas Christian University
Farah Qureshi, Educational Testing Service
Thomas Jenkins, Educational Testing Service
ABSTRACT:
This study describes how we developed and collected preliminary validity evidence for a learning progression (LP) for systems thinking in ecosystems. In particular, the LP focuses on how middle and high school students use discipline-specific systems thinking concepts (e.g., feedback loops and energy pyramid) to analyze and explain the interdependent relationships in ecosystems and humans' impact on those relationships. We conducted two cycles of research. In the first cycle, we developed an initial LP based on clinical interview data. In the second cycle, we revised and validated this LP based on both interview data and assessment data. The final LP contains four levels that describe increasingly sophisticated reasoning patterns that students commonly use to explain phenomena about interdependent relationships in ecosystems. The Wright Map was used to evaluate the validity of the LP. Using the LP, we also compared the performance of students from different subgroups (e.g., SES, gender, school settings). The data suggests performance gaps for students from low SES and students from urban schools, but not for other traditionally under-served student groups such as female students and students from rural schools.

Role of Imaginary Play in the Zone of Proximal Development and Science Learning
Michael Kamen, Southwestern University
Mary E. Rouhiainen, Southwestern University
ABSTRACT:
Imaginary play is often reported as an important element in children's social and cognitive development. Yet, many early grade classrooms provide fewer opportunities for imaginary play. One sees few classrooms, even at the kindergarten level with unit blocks or a center for dramatic play available for free play. Vygotsky discussed how pretend play allows a child to behave "beyond his average age, above his daily behavior; in play it is as though he were a head taller than himself," in essence creating a new zone of proximal development. In this study four 7-8 year old children were played together with a variety of materials. The researchers set up a number of activity areas that were intended to prompt various degrees and types of imaginary play. The children were video recorded during their play and interviewed at the end of their play session. Contextual connections between the children's imaginary play, children's perceptions of themselves as scientists, and science concepts are described in detail with emergent themes suggesting

ways for classroom teachers to enhance science learning through careful selection of materials for free play and intentional interactions with children during their imaginary play.

Role of Mathematical Complexity on Students' Problem Solving Approaches to Synthesis Physics Problems
Bashirah Ibrahim, The Ohio State University
Lin Ding, The Ohio State University
ABSTRACT:
We explore students' approaches to quantitative synthesis problems with varying mathematical complexity, simple, medium and complex. Synthesis problems comprise multiple concepts, typically taught in different chapters. Mathematical complexity refers to the number and the type of equations that are manipulated concurrently. Thirteen students, from a second year calculus-based physics course, were interviewed individually. They were randomly assigned one of the three synthesis problems. Results indicate that the students used four problem solving approaches: trial and error, flawed reasoning, knowledgeable, and expert-like approach. Students completing the medium and complex tasks mainly used the "trial and error" and "flawed reasoning" approaches. Those solving the simple task used the four approaches. The students could identify the pertinent concepts but failed to correctly apply them. They made similar conceptual mistakes across the three tasks. An implication of this study is maximising problem solving as a learning as well as an assessment tool.

Student Learning of Graphing Skills in Conjunction with Instructional Feedback
Nirit Glazer, SVN
Yariv Glazer, SVN
ABSTRACT:
This paper examines the challenges that students from introductory college chemistry courses exhibited when tasked with generating graphs. This practice, which heavily involves data-creation and data-analysis skills, was studied through an examination reflection. The activity described explores the value of graphing and data visualization skills as a connection between science content with student life skills. This study has two complementary goals. First, it aims to make introductory science classes more relevant and valuable for student life through the use of graphing skills, and second, to use visual data to enhance student learning of the scientific concepts. Students received individual feedback on their graphs. Student graphs were then shared in the class (anonymously), and specific guidelines were given on how to improve the graphs, e.g., how to improve the axis labeling, title, legend, and chart type. Analyzing student graphs also reveals common difficulties with graph creation. Results show a clear progression with student acquisition of graphing skills, although some problems commonly persist, such specifying the units. Further related findings will be presented in greater detail at the conference presentation.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

The Choice to Remain in STEM: A Characterization of Transfer Students' Experiences
Terrell R. Morton, University of North Carolina, Chapel Hill
Lisa A. Corwin, University of Colorado, Boulder
Cynthia Demetriou, University of North Carolina, Chapel Hill
A. T. Panter, University of North Carolina, Chapel Hill
ABSTRACT:
This study provides preliminary findings about perspectives of students who started and remained in a STEM major upon transferring to a new institution. Through interviews and inductive qualitative analyses, we identified challenges, relationships, and institutional affiliation represent the high-frequency codes. Using these categories, superimposed on a Phenomenological Variant Ecological Systems Theory conceptual framework, we describe potential influential factors on students' decisions to stay in a STEM major, their influence on students' perception and experience, and how they impact student response and outcome about their decisions to remain in their STEM major upon switching institutions.

The Rural Effect: How Students' STEM Perceptions are Influenced by Attending a Rural High School
Ben Pitchford, Colquitt County High School
Regina Suriel, Valdosta State University
ABSTRACT:
This mixed-methods study examined the perceptions of students from a rural area regarding STEM and STEM careers. STEM perceptions of high school students from a rural setting were determined using the STEM Semantics Survey. Results of a MANOVA indicated that males had statistically significantly more favorable perceptions of STEM and STEM careers overall. Females perceived engineering significantly less positively than did males. College students who attended the same rural high school as the high school student participants also completed the STEM Semantics Survey. Results of the survey were used to develop interview questions for the college students. Interview data from the college students revealed strong beliefs that, because they attended a rural high school, they had fewer, less engaging, and less rigorous STEM experiences than college students they knew who had attended more urban

high schools. This rural effect permeated all discussions of their STEM perceptions. Having few STEM role models in their community, limited STEM resources in their school and community, and a community that did not place a high value on STEM were mentioned by college students as influencing their perceptions of STEM and STEM careers.

Theoretical Proposition: INPLACE Mobile Games Promote Collaborative Learning Through Cooperation, Social Flow, and Effective Communication
Denise M. Bressler, The State University of New Jersey
ABSTRACT:
According to the National Research Council, the ability to collaboratively solve problems is of the utmost importance in scientific careers. Unfortunately, students are not exposed to effective collaborative learning environments and there is still much to know about the nature of such environments. Essentially, there is a need to uncover the complicated relationships of social contexts and communication that occur in collaborative learning environments so that we can design effective collaborative learning environments and better prepare our students for scientific careers. Previous research using mobile games specifically designed for collaboration—called INPLACE mobile games—revealed that such games can be used to promote scientific practices and high learner engagement. This theoretical paper synthesizes prior research relating to cooperation, communication, and social flow and proposes a model for how and why collaborative learning takes place in INPLACE mobile games. Uncovering the mechanisms for how and why collaborative learning takes place will enable future games and similar learning environments to be designed to afford such desired learning outcomes.

Transfer of Intellectual Resources between Science and Mathematics: Development and Validation of a Theoretical model
Kyungwoon Seo, Minnesota State University, Mankato
Kyong Mi Choi, University of Iowa
Brian M. Hand, University of Iowa
ABSTRACT:
The purpose of this study was to build and empirically examine the validity of the theoretical framework of how intellectual resources (IR) are transferred across the disciplines of science and mathematics. Based on the work of Bailin (2002; 2007) and Mulnix (2012), and with the adoption of TIMSS 2011 Assessment Framework, the theoretical framework composed of two parallel epistemic practices were developed: searching for reasons and giving reasons. IRs centered on "searching for reasons" were the inductive inference in mathematics and abductive inference in science, while those concerned with "giving reasons" were the deductive inference in both disciplines. The model was empirically tested with 9,300 fourth grade students' standardized assessment data using Confirmatory Factory analysis and Structural Equation Modeling. Results showed that the model was evaluated to be within the acceptable range, indicating that the fourth-grade students do utilize the two epistemic practices. Furthermore, development of the epistemic practices in science was shown to have a positive influence on the development of the practices in mathematics. That is, a fourth grader's ability to search and to give reasons in science affects his or her ability in those epistemic practices in mathematics. Pedagogical implications of the findings are further discussed.

Wading into the River: Girls Exploring Future Possible Selves in a Geoscience/Biology/Technology Summer Program
Suzanne Perin, University of Alaska, Fairbanks
Laura Conner, University of Alaska, Fairbanks
Laura Oxtoby, University of Alaska, Fairbanks
ABSTRACT:
Despite huge advances in equitable gender representation in some STEM careers, there remain woeful gender gaps in many STEM fields. We turn to identification with science as a means of investigating this issue of girls' participation in science, applying a situative approach to learning during an all-girls summer STEM program. We present a case study of two girls who participated in the program who found different aspects of authentic scientific practices to be the most memorable because it allowed them to "try on" identities of future possible selves. Engaging in these physical, authentic activities, the girls tested and liked or disliked multiple roles – literally, by wading into the river, collecting data and presenting, they were trying on roles of biologists and geoscientists as possible selves and experiencing the practice of science in ways unavailable to them in school. Our analysis suggests that this designed learning environment provides important opportunities for identity work. The findings from this study have implications for the design of out-of-school time learning environments and for understanding the identity development of students in relation to participating in field-based science and gender-based stereotypes in the sciences and technology fields.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Testing Our Assumptions about Teaching Philosophy and Nature of Technology to Elementary Students
Kayla K. Brauer, Drake University
Jerrid W. Kruse, Drake University
Renald Daemicke, Drake University

Mitchell Klocke, Drake University
Megan Wagner, Drake University
Jesse L. Wilcox, Drake University
Colin Seebach, Bergman Academy
Jaclyn Easter, Drake University

ABSTRACT:
Nearly 20 years ago, the American Association for the Advancement of Science (AAAS) called for the inclusion of the philosophy and nature of technology (PNOT) in science education (AAAS, 1989). Unfortunately, the link between engineering in recent science education reform and the PNOT understanding called for by the AAAS has not been made and PNOT ideas are not found to be a common desired outcome of engineering education in the current literature. While we might assume the explicit/reflective framework from the nature of science literature applies to PNOT, this assumption has not been empirically supported. Therefore, this study seeks to compare engineering instruction with an explicit/reflective PNOT approach to engineering instruction without an explicit/reflective PNOT approach. Using a pretest/posttest, control/treatment design, this quasi-experimental study found that the explicit/reflective framework was extremely effective for teaching PNOT ideas to the 5th grade students. However, students continued to struggle with some aspects of PNOT and nuances within PNOT ideas.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Local Factors Hindering Transitions towards NGSS and STEM Practices for Middle School Science Teachers
Issam H. Abi-El-Mona, Rowan University
ABSTRACT:
This qualitative study seeks to understand middle school science teacher participant perceptions and underlying factors impacting their adaption or implementation of using Next Generation Science Standards (NGSS) as well as informing the structuring of an innovative curricular model (STEEM-S IMPACT) for engaging teachers and students in STEM practices that align with NGSS. Research questions investigated were: (1) What existing factors hinder or facilitate the implementation of NGSS and STEM practices in middle school science teachers' classrooms? (2) What are middle school science teachers' perceptions of the use and implementation of the STEEM-S IMPACT model in light of the necessity to adopt NGSS and the need for STEM education practices? Participants included two public school teachers in New Jersey. Data collection included a Likert scale survey on teacher perceptions, post professional development survey; pre and post semi-structured 40 minute interviews and field notes of classroom observations across 8 months. Data analysis focused on thematic analyses of generated statistically significant themes, followed by data triangulation of all data sources. Findings indicate that transitions towards the implementation of NGSS in the classroom involved a multitude of localized and state policy factors hindering or at times facilitating the application of NGSS.

Pilot Instrument for Measuring Physics Teachers Knowledge of Formative Assessment of Force and Motion
Marilyn M. Stephens, University of Alabama
Dennis Sunal, University of Alabama
Cynthia Szymanski Sunal, University of Alabama
Jim A. Minstrell, FACET Innovations
James W. Harrell, University of Alabama
ABSTRACT:
This study involves the development and validation of an instrument to measure physics teachers' formative assessment knowledge as an important component of their pedagogical content knowledge (Shulman, 1986; 1987; Magnusson, et al.,1999). The Next Generation Science Standards call for assessment to meet all of the goals of science education. Assessments must determine what the students know, provide feedback and facilitate learning. The importance of an instrument which measures physics teachers' topic specific assessment knowledge and how they incorporate it into their pedagogical content knowledge (PCK) is critical for science teacher education programs and professional development programs to ensure effective physics instruction.

Restate, Answer, Cite, and Explain Paragraphs as Written Argumentation in Eighth Grade Physical Science
David L. Pauli, University of Georgia
ABSTRACT:
Restate, Answer, Cite, and Explain (RACE) paragraphs are a tool that teachers use to help students organize and make sense of scientific content, yet these paragraphs have not been previously researched. The format of these paragraphs suggests a link to written argumentation where Restate and Answer relates to claims, Cite relates to evidence, and Explain relates to reasoning. This quasi-experimental investigation took place in two eighth grade physical science classrooms. The treatment class used RACE paragraphs to make sense of two topics about nuclear processes while the non-treatment class used recall and analysis questions to make sense of the same topics. This research shows that RACE paragraphs produced weak arguments as measured by the Total Argumentation (TA) and Holistic Argumentation (HA) rubrics developed by Choi, Notebaert, Diaz, and Hand (2010). Additionally, RACE paragraphs did not promote student learning overall, but there was a moderate correlation between the TA score for one of the RACE paragraphs and

student learning. Implications of the results on RACE paragraphs and the connection to argumentation and writing to learn in science are discussed.

Science with a Smile: Humor as Antidote to Depressed Achievement in and Poor Attitude to Perceived Difficult Science Concepts in Nigerian Schools
Peter A. Okebukola, Lagos State University
ABSTRACT:
In the quest for a more potent tool for improving achievement and attitude of students to perceived difficult concepts in science, this study investigated the impact of humor and amiable science using 253 Nigerian senior secondary students in experimental and control classes. Results of the MANCOVA applied on the achievement and attitude data of boys and girls in the sample showed significant Wilks' lambda (F=10.24; p.05). Qualitative data from field notes and videotaped class transactions showed the positive effect of the combination of non-distractive, content-specific humor and amiable science on lowering tension in class, elevate class participation and promote students' enthusiasm to learn science. Implications of the findings for science teacher preparation and further research are drawn including a call for further testing of the combination therapy of amiable science plus humor.

Using Choice to Uncover the Role of Gender Stereotypes in High School Physics Assignments
Samuel Wheeler, North Carolina State University
Margaret R. Blanchard, North Carolina State University
ABSTRACT:
This study investigates the role that student choice and gender stereotype have on student interests, beliefs, conceptual understanding, and motivation toward learning physics in a high school unit on Newton's Laws. This explanatory, mixed methods study examined how giving students a choice in the context of physics problems influenced their attitudes, interest, and performance. Seventy-four student participants in high school physics classes, from five US states, took part in this study. Homework problems were created on WebAssign, were designed to investigate the role that the context of a question has on which type of physics problem students prefer, developed from recommendations in the literature on gender preferences. Three contexts were used: traditional physics; biology; sports. Participants were given pre/post FCI to evaluate physics conceptual knowledge, and pre/post CLASS to measure changes in attitudes. Female participants did as well as males in all but 3 problems where male students scored higher based on two sample t-tests. Participants reported they were less satisfied with why something works until they understood the way that something worked and that they were more likely to think about which physics concept to apply to a problem than before.

Using Resource Teams to Integrate Computational Thinking into NGSS Aligned Investigations for K-12 Classrooms
Danika N Korpacz, University of Rhode Island
Jay A. Fogleman, University of Rhode Island
ABSTRACT:
American students need better opportunities to do and learn science. The release of the NGSS has highlighted a need to support students engaging in authentic science and engineering practices, including computational thinking (CT). CT refers broadly to a person's ability to apply computational methods to everyday problem-solving, a skill that should be accessible to everyone, not just computer scientists. This study describes efforts within a math-science partnership (MSP) to use a resource team approach to increase teachers' capacity to integrate CT and aspects of NGSS into their middle and high school science classrooms. Middle and high school teachers collaborated with local science faculty to develop computationally-rich NGSS-aligned investigations that addressed locally relevant questions such as: How will sea level rise affect local coastal water levels? A survey was developed based on classroom applications of nine CT elements, including: data collection, data analysis, data representation, problem decomposition, abstraction, algorithms, automation, simulation and parallelization. Teachers were surveyed about their CT knowledge and self-efficacy before and after developing their investigations, and about their subsequent enactment of their investigations. Results suggests that teachers' self-efficacy in CT is initially much lower than that of their higher education colleagues.

Effects of Culturally Responsive Teaching on Nature-of-Science Thinking in an Anatomy and Physiology Classroom
Heidi Cian, Clemson University
ABSTRACT:
Understanding the nature of science (NOS) requires realization that scientific facts are transient and culturally embedded. Despite its significance to the understanding of science, it is a difficult concept for many teachers in high school classrooms. Culturally responsive practices are implemented with the objective of prompting students to challenge their assumptions about their perceptions, but it is often not used in science classes. Given that both culturally responsive practices and NOS aim to challenge students to think beyond what is immediately visible, research is needed to see how the two may complement one another. This qualitative study explored whether a culturally responsive approach to teaching influenced students' ability to think in alignment with nature-of-science. Students in two high-school anatomy classes were taught about the digestive system and nutrition. In one class, a culturally responsive approach was employed, focusing on nutritional perspectives from Traditional Chinese Medicine (TCM) and holistic Indian medicine, or Ayurveda. In the other class, students were taught about nutrition based exclusively on Western perspectives. Data included nature-of-science surveys and teacher field notes. Preliminary findings suggest that instructional strategies that employ cultural context may improve students' ability to think scientifically.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Exploring College Students' Written Arguments Generated During an Environmental Science Course
Lauren H. Swanson, Whittier College
Ruben Solorza, Whittier College
Cinzia Fissore, Whittier College
ABSTRACT:
This study explored written work produced by college students enrolled in an environmental science course. Artifacts included short-essay prompts assessing participants' ability to apply their knowledge of soil science to real-life scenarios. In these prompts, students were asked to make and justify claims; at times students were asked to provide a counterargument. The open-ended nature of the prompts highlighted variation in students' ability to showcase their understanding of science concepts when engaging in these aspects of argumentation. Furthermore, students struggled to construct counterarguments. Implications from this study extend to both assessment design and teacher practice.

Monitoring Students' Atom Model Change via Model-based Inquiry
Tugba Yuksel, Purdue University
Lynn A. Bryan, Purdue University
ABSTRACT:
This research is part of a larger study that examines students' cognitive structures and reasoning of fundamental quantum mechanics concepts as they engage in a model-based inquiry instruction. In this research, we investigated how undergraduate freshmen level students' cognitive understanding about atomic structure evolves when they were encouraged to use physical representations of early atomic models. A model-based framework for this project was adopted to facilitate students understanding of as well as interest in science learning. With physical models and computer-based simulations, students had a chance to imitate Thomson and Rutherford experiments. In this paper, we analyzed students' model development progress by using case study approach. The findings indicated that students who received model-based learning module (MBLM) showed a drastic change in their existed model of atom toward scientific model in compare to traditional group.

Where's the Reflection? A Critical Literature Review of University Science Service-learning Experiences
Gretchen P. King, University of Georgia
ABSTRACT:
Researchers have found that service-learning courses increase a student's awareness of diversity, self-efficacy, and engagement in the community. As a result, science content courses are more frequently incorporating service-learning pedagogy into the curricula. However, service-learning is a fragmented idea, researchers defining the important components in different ways. Reflection is considered one of the critical components for meaningful service-learning. In this critical literature review, 15 articles were examined for their definition of service-learning, course objectives, and use of reflection. While most of the articles reviewed did not mention reflection in their definition of service-learning, reflection was used in three-fourths of the articles in some capacity. Reflection was rarely used as a data source for articles, but as a supplement for data gathered in some other way. It was under-utilized for both research and student learning.

Scientific Reasoning Among Undergraduate STEM Majors
Katherine Mollohan, The Ohio State University
Lin Ding, The Ohio State University
ABSTRACT:
While it is obvious to researchers and instructors that scientific reasoning is crucial to become a practicing scientist, understanding how undergraduate students improve in scientific reasoning skills is not a prevalent line of research. This study examines the similarities and differences of undergraduates' scientific reasoning skills, as measured by the Lawson Classroom Test of Scientific Reasoning (LCTSR), across four STEM majors and across all four years of undergraduate coursework. Physics majors exhibited the highest scores on the LCTSR across all four years, followed in order by engineering, chemistry, and biology. For all four majors, there is relatively little variation in their reasoning skills between freshman and senior year. In all, data show that while the year in school does not significantly affect reasoning skills, students' selection of major does. Educating students to be proficient in reasoning has implications for all future workforce development, not just future scientists.

The Process by which Faculty Members Adopt Innovative Teaching Practices
Gili Marbach-Ad, University of Maryland
Carly Rietschel, University of Maryland
ABSTRACT:
Despite robust evidence documenting the superiority of student-centered teaching approaches over instructor-centered approaches, instructors continue to adhere to lecture modes of teaching. Given that many instructors face challenges while implementing evidence-

based teaching approaches in their classrooms, there is a need to explore their experiences and learn what support instructors need as they engage in the process of transforming their courses. In this study, we employed a case study approach to obtain an in-depth understanding of the change process of two university instructors who were involved with redesigning a biology course. We also interviewed a graduate teaching assistant and undergraduate learning assistant to gain their perspectives on teaching the course. Using the Innovation-Decision Model for change, we explored the motivation, challenges, and thought processes of the instructors through two consecutive course offerings. Our data show that there are a multitude of supports, barriers and motivations that impact adoption of evidence-based teaching practices. Supports for change include funding, instructor recognition, and training programs for undergraduate teaching assistants, as well as availability of a teaching and learning center staff member or a discipline based education researcher who could support instructors in redesigning and implementing course innovations.

How Feelings about Student-centered Strategies Affect Actual Implementation
Eugene Judson, Arizona State University
Lydia Ross, Arizona State University
Stephen J., Arizona State University
James A. Middleton, Arizona State University
ABSTRACT:
Dispositions of 286 engineering faculty members were assessed to determine views about three student-centered classroom strategies and how frequently faculty used those strategies: (1) using formative feedback to adjust instruction, (2) integrating real-world applications, and (3) promoting student-to-student discussions during class time. The Value, Expectancy, and Cost of Testing Educational Reforms Survey (VECTERS), based on expectancy theory, was designed, tested, and validated for this purpose. Data were examined at an inclusive level but also analyzed to determine gender-based differences among engineering faculty. Overall results indicate usage of student-centered strategies is significantly tied to perceived benefits and expectation of success. Using student-centered strategies are inversely related to the perceived cost of implementation – with more frequent users perceiving lower cost of time and materials. Although men and women reported using student-strategies nearly equivalently, women had significantly higher expectations of success for the implementation of formative feedback and real-world applications. Similarly, women indicated that using the strategies of formative feedback and real-world applications had significantly greater value. Also, men were significantly more inclined to view the physical setup of their classroom as hindering implementing formative feedback or initiating student-to-student discussions.

Undergraduate Students' Use and Understanding of Scientific and Popular Media Articles
Diane Lally, University of Nebraska, Lincoln
Jaime L. Sabel, University of Memphis
Cory T. Forbes, University of Nebraska, Lincoln
ABSTRACT:
Unlocking information found in scientific articles is the key to science literacy. In order to achieve scientific literacy, students need to be able to read, analyze, and use the information found in scientific articles. One of the ways in which students use these articles is in decision making regarding water-related socioscientific issues (SSIs). However, students have difficulty understanding, analyzing, and using scientific articles. More work is needed to uncover the supports needed to help students engage with and effectively use scientific articles. In this study, we investigated students' information requirements for decision making, effective use of resources in considering additional information required for decision making, and the extent to which student use of resources relates to decision making about a water based SSI. We show that students' information requirements for decision making can be consolidated into six themes relating to a water based SSI with responses split between efficient and inefficient text resource use. Efficient resource users are more effective than inefficient users in providing subjective criteria in support of their decisions regarding water-related SSIs. Findings contribute to the evolution of science literacy and scientific article understanding, analysis, and use at the undergraduate level.

Science Divorced from Its Philosophy: Turkish Undergraduate Physics Students' Views of Science
Deniz Gurcay, Hacettepe University
Mehmet Aydeniz, University of Tennessee
ABSTRACT:
The purpose of this study was to assess 138 Turkish undergraduate physics students' understanding of the nature of science (NOS). Participants' NOS views were measured through VNOS-C questionnaire. The results show that the majority of participants' hold naïve views related to most NOS tenets. More specifically, while the majority of students emphasize the objective and empirical nature of science, they fail to acknowledge the role of arguments in science. The majority attributes the certainty and durability of scientific knowledge to the experimental evidence and fails to recognize the role of debate and critique in science. The majority also believes that there is a hierarchical relationship between scientific theories and scientific laws in that scientific laws are matured forms of scientific theories and there is much more experimental support for scientific laws than there is for scientific theories. While the majority acknowledges the role of creativity, and imagination and sociocultural values in science, they hold naïve views about these tenets of science. Our discussion focuses on the possible causes for these alarming results and suggestions for bringing about improvements in undergraduate students' NOS views.

Strand 6: Science Learning in Informal Contexts
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Reframing Massive Open Online Courses as Free-choice Learning Environments
Sanlyn R. Buxner, University of Arizona
Matthew C. Wenger, University of Arizona
Chris D. Impey, University of Arizona
Martin Formanek, University of Arizona
ABSTRACT:
Massive Open Online Courses (MOOCs) are designed to be free and open to anyone around the world and thus are aimed at large participation. MOOCs are part of an educational industry that includes a growing number of universities. Although they resemble formal classes, MOOCs are of interest to educational researchers because they attract more than traditional undergraduates students as out-of-school learning environments where people learn science, particularly adult learners. This research project examined learners in an astronomy MOOC in order to better understand the motivations of MOOC learners in relation to those in formal educational environments and ultimately to develop courses that better meet the needs of our learners. Our results show that our MOOC learners had high intrinsic motivation, self-efficacy, and self-determination, and contrasted with formal learners by having lower grade and career-related motivations. Additionally, our MOOC learners were more likely to have identities of Explorers, Hobbyists, Spiritual Pilgrims, and Experience Seekers, and less likely to be Facilitators or have Career related goals and identities. These results suggest that MOOC learners have characteristics of free-choice learners, and it may be beneficial to study learning in these environments using a framework designed to study other free-choice learning experiences (like museums).

Shifts in Students' Views towards Engineering in an Out-of-School-Time Program
Richard Gearns, Stony Brook University
Angela M. Kelly, Stony Brook University
Monica Bugallo, Stony Brook University
ABSTRACT:
There has been a chronic shortage of engineering talent in the U.S., and more diverse students must be attracted and retained to expand the technological workforce. To address this challenge, university educators and researchers designed and implemented an electrical engineering program for high needs secondary students using a theoretical framework which synthesized elements of the expectancy-value model and the theory of planned behavior. The goal of the six-week afterschool program was to expose sophomores and juniors to the challenge, passion, and opportunity of engineering by introducing students to core engineering concepts and guiding them to design and modify innovative projects in electrical engineering. Students also met engineering professionals and discussed academic pathways for engineering careers. Research questions addressed students' perceptions about participation and success in engineering. The study is descriptive-exploratory research that lays the groundwork for assessing the outcomes of an out-of-school-time electrical engineering program that may be later replicated and scaled. Qualitative data from 24 focus group participants revealed improved student attitudes towards engineering study and careers. Coded focus group transcripts revealed three themes among participants that included engineering related interests, engaging programmatic aspects, and positional academic and career advantage. These themes will be further analyzed and implications discussed.

The Impact of Organizing Middle and High School STEM Clubs on Undergraduate STEM Majors
Bryan Shao-Chang Wee, University of Colorado, Denver
Michael Ferrara, University of Colorado, Denver
Michael Jacobson, University of Colorado, Denver
Hillary Mason, University of Colorado, Denver
Ronald Rorrer, University of Colorado, Denver
Robert M. Talbot, University of Colorado, Denver
ABSTRACT:
The need for a larger, well-trained U.S. STEM workforce is becoming increasingly acute, including a clear need to recruit and retain a larger and more diverse population of undergraduate STEM majors. While efforts to address this issue in the traditional P-16 classroom are important, it is also critical to explore other promising initiatives that have the potential for high impact. (Project) at (university) is currently undertaking an investigation to study the impacts of developing and implementing K-12 outreach, specifically middle and high school STEM clubs, on undergraduate STEM majors. Each of the 5 project clubs in 2015-16 was organized and led by a team of 2-4 Undergraduate STEM Fellows, and in 4 of 5 clubs, a Graduate Facilitator. Through case studies built upon data from reflective journals, interviews, and other data sources, the project is investigating the impact that leading STEM outreach has on the undergraduate Fellows. Here, we give an overview of the project's first year (2015-16), and discuss results that demonstrate growth in the Fellows' metacognition, content knowledge and communication skills.

Youths Learning to Communicate with the Public about Science
Leah A. Bricker, University of Michigan

Benjamin L. Tupper, University of Michigan

ABSTRACT:
This proposed poster documents an exploratory qualitative study of youths' public communication of science at a zoo. The research questions that guided the preliminary analysis are: (a) How do youths in a zoo program focused on animal care, conservation, leadership, and active participation in a democracy learn to publicly communicate about science, and (b) What are youths' perceptions about what they are learning through their science communication-related activities and whether/why those learnings are important to them? Data stemmed from an observation of a training for participating youths that was facilitated by program staff and that focused on strategies and techniques for engaging zoo visitors in discussions about animals and conservation. Data also stemmed from two focus with participating youths that focused on youths' perceptions of their experiences communicating with zoo visitors, how they learned to do that work, what they found valuable about participating, and what challenges they had encountered. Preliminary findings included youth-reported: (a) school-related benefits from program participation, (b) challenges related to adults taking them seriously, and (c) specifics related to how to teach other youths how to do this type of work. Implications and potential contributions of this preliminary research are discussed.

Strand 7: Pre-service Science Teacher Education
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Are We Opening the Science Pipeline? Putting a Magnifying Lens on Early Science Teacher Education
Jennifer Gallo-Fox, University of Delaware
Lauren Stegeman, University of Delaware
Andrea Drewes, University of Delaware
ABSTRACT:
This poster session will provide information about the importance of science teacher education for early childhood education and the need to support both children and families to engage young children in science. Challenges and opportunities for addressing this important area will be addressed and a theory of action will be presented. Information is designed for teacher educators and anyone who works with young children and families in formal or informal settings. This poster session will present the challenges for the field of early childhood science teacher education, and present a multi-faceted working theory of action that is based on the research literature and designed to identify changes that can help strengthen the field of early childhood science. This theory of action forms the foundation for preliminary work occurring within an early childhood teacher education program.

Learning to Teach Science to English Language Learners: A Study of Preservice Teachers
Walter Aminger, UCSB
Stacey L. Carpenter, University of California, Santa Barbara
Sarah Hough, University of California, Santa Barbara
Ashley Iveland, University of California, Santa Barbara
Valerie Meier, University of California, Santa Barbara
Sungmin Moon, University of California, Santa Barbara
Julie A. Bianchini, University of California, Santa Barbara
ABSTRACT:
We investigated what eight preservice secondary science teachers learned about effective instruction for English language learners (ELLs) over the course of a 13-month, post-baccalaureate teacher education program. To do so, we conducted interviews with preservice teacher participants, as well as their mentor teachers and teacher education instructors; videotaped three classroom lessons; and collected their edTPA (teacher performance assessment) portfolios. From our qualitative analyses of these data, we identified both strengths and limitations in preservice teachers' understanding of four dimensions of effective ELL instruction: academic language demands, opportunities for rich use of language, cognitively demanding tasks, and students' funds of knowledge. We also compared preservice teachers' understanding of how to teach ELLs to those of their mentor teachers and teacher educators. Further, we determined how the teacher education program itself supported and constrained preservice teachers' learning of effective science instruction for ELLs. We close with implications for how teacher education courses and field work experiences can strengthen preservice teachers' understanding of effective science instruction for ELLs.

Pre-service Science Teachers' Trustworthiness Evaluations of Texts on a Pseudo-scientific and a Socio-scientific Topic
Mehpare Saka
Deniz Sarba
ABSTRACT:
It is crucial to use pseudo-scientific issues as well as socio-scientific issues during teaching and evaluating NOS for characterizing NOS by evaluating trustworthiness of claims in real life. The aim of study was to investigate pre-service science teachers' positions and trustworthiness evaluations of the claims in the texts on a pseudo-scientific and a socio-scientific topic. The analyses of participants' assignments showed that majority of the participants were opponent of constructing nuclear power plants while very few of them were opponent of the view that the shapes of water molecules are influenced by good and bad words. Results also showed that

pre-service teachers are aware of the criteria to evaluate the trustworthiness of information. Participants seem to have understood the significance of evidence to support claims as the majority of them mentioned it for both of the articles. However, the number of participants who discussed bias and trustworthiness of the source in the article about power plants are greater than those that mention in the article about water. Results indicate the necessity of discussing trustworthiness of the claims in the context of not only socio-scientific issues, but also pseudo-scientific issues in teacher education courses.

Recognizing Student Understanding from Assessment: Chemistry Pre-service Teacher's Competencies
James M. Nyachwaya, North Dakota State University
ABSTRACT:
This study explored four secondary pre-service chemistry students' understanding of the particulate nature of matter, PNM. The study also looked at the extent to which the pre-service chemistry students were able to analyze and evaluate student drawings drawn from chemistry education research literature, which were based on PNM. Study participants were also asked to describe how they would go about addressing any student misunderstandings, errors or misconceptions they saw in the drawings. Results show that two of the participants did not provide appropriate particulate drawings of solid ionic compounds in two equations. While participants were able to identify errors or mis/understandings in the drawings, some often focused on a few features of the drawings, missing very fundamental important aspects of the drawings. Those who did not provide appropriate particulate drawings of particular reactants and products were not able to flag errors involving those very compounds in the drawings provided, which contained errors they themselves had in their drawings. Proposals on how to address student errors and misunderstandings from the drawings varied, with some students proposing hands-on activities, demonstrations and simulations, while others proposed to use 'logic' in their instruction.

Prospective Science Teachers' Knowledge of Science Practices Situated in the Classroom
Barbara A. Crawford, University of Georgia
Robert Idsardi, University of Georgia
Camela Kiernan, Rochester Institute of Technology
ABSTRACT:
Research in teacher education is unclear on how to effectively support science teachers in engaging their own students in inquiry/science practices (SP), as advocated in the United States Next Generation Science Standards (NGSS Lead States 2013). The purpose of this study is to explore prospective secondary science teachers' knowledge of SP and views of teaching SP, to better understand how to effectively support novice teachers. During inquiry, learners use critical thinking skills, ask questions, plan and carry out investigations, grapple with data, build and use models, use evidence to justify explanations, and engage in argumentation with peers to make sense of the natural [and material] world with the expert guidance of a teacher. The research question was, in what ways do prospective science teachers understand SP situated in the classroom? This study utilized a grounded theory method (Corbin & Strauss, 2014), using pre-/post-tests, participants' lesson plans, course artifacts (e.g. reflections with questions probing participants' knowledge of SP), and interviews. Findings suggest prospective teachers should be given opportunities for in-depth reflective discussions of SP situated in the context of their own teaching and the need for ongoing and robust support.

Understanding the Practices of Science and Engineering: Perceptions of Teachers Across the Learning-to-Teach Continuum
Alexandria K. Hansen, University of California, Santa Barbara
Sungmin Moon, University of California, Santa Barbara
Ashley Iveland, University of California, Santa Barbara
Stacey L. Carpenter, University of California, Santa Barbara
Danielle Boyd Harlow, University of California, Santa Barbara
Julie A. Bianchini, University of California, Santa Barbara
ABSTRACT:
This study investigated teachers' perceptions of the science and engineering practices described in the Next Generation Science Standards (NGSS) across the learning-to-teach continuum. Specifically, this study examined a year-long scholarship program situated in two high schools' STEM-focused academies. The program supported prospective teachers (undergraduates not yet enrolled in a teacher credential program) and preservice teachers (graduate students enrolled in a teacher credential program) in working with experienced, mentor teachers in their chemistry, physics, and engineering classrooms. All three groups of teachers were periodically interviewed about their experiences and understanding of the NGSS practices. Our qualitative analysis of data focused on changes in teachers' understanding of the two practices that are explicitly differentiated for science and engineering: Practice 1, asking questions (for science) and defining problems (for engineering): and Practice 6, constructing explanations (for science) and designing solutions (for engineering). As expected, interviews revealed that preservice and mentor teachers held more nuanced and accurate understandings of these two NGSS science and engineering practices than prospective teachers. Still, some prospective teachers' understanding evolved into alignment with the NGSS as more time was spent in classrooms. We close with implications for teacher education programs and professional development efforts.

Strand 8: In-service Science Teacher Education
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Fostering Teachers' Autonomous Motivation and Development: A Self-determination Theory Perspective
Keith Power
Karen Goodnough, Memorial University
ABSTRACT:
Using a self-determination theory lens, this case study analyzed the impact of a science, engineering, technology and mathematics oriented professional development program on six primary teachers' autonomous motivation as they participated in a collaborative action research project. In particular, the study focused on the contextual factors of the program that either supported or thwarted the teachers' psychological needs to feel competent, related, and autonomous during the project. Through qualitative case study methodology the outcomes revealed that the program was successful in accommodating the teachers' needs. The teachers reported that the program supported their volitional will to engage in self-directed learning by offering them choice, encouragement, and constructive feedback. The teachers were also provided with ample time and resources to enhance their instructional knowledge and showcase their new skills. Moreover, the teachers were able to strengthen existing relationships and expand their professional community. These relationships provided additional support for the teachers and contributed to their overall learning and development. Overall, this study contributes to our understanding of how teachers may learn when engaged in professional learning initiatives and the conditions that promote this learning.

Growth in Elementary School Teachers' Views of Science and Engineering Practices
Augusto Z. Macalalag, Arcadia University
Augusto Z. Macalalag, Arcadia University
Katie Miller, Arcadia University
ABSTRACT:
The Framework for K-12 Science Education was published by the National Research Council (2012) to guide educators on incorporating the science and engineering practices in classrooms. According to the Framework, teachers are encouraged to engage students in the following practices: (a) defining problems, (b) developing and using models, (c) planning and carrying out investigations, (d) analyzing and interpreting data, (e) using mathematics and computational thinking, (f) designing solutions, (g) engaging in argument from evidence, and (h) obtaining, evaluating, and communicating information. Unfortunately, most elementary students have received little exposure to and instruction in using these practices, which may be due in part to a limited of knowledge and pedagogy of teachers in the domain. To address this challenge, we used the Framework to guide our teachers' knowledge development of and experiences in the EDP in a 3-credit graduate course: Introduction to STEM Education. In this paper we describe the growth of teachers' views of the practices based on our analyses of their reflections submitted on the first and last day of the course. Our findings suggest the positive contributions of the course in helping the teachers develop more positive views toward teaching the science and engineering practices.

Impact of a Professional Project in Terms of LPoSMC on Novice Physics Teachers: Results of a Randomized Controlled Trial
Xiaoming Zhai, Beijing Normal University
Yuying Guo, Beijing Normal University
Min Li, University of Washington
ABSTRACT:
The impact of learning progression on teachers' professional development intrigues researchers in science education recently. This study, by means of a randomized controlled trial, investigates the impact on novice physics teachers after a professional workshop in terms of learning progression of scientific modeling (LPoSMC) competence. We included an experiment group that participated in our professional learning workshop and a control group with a comparable background but did not attend the workshop. By analyzing their evaluation and revision of instructional plans, we compared the experiment group and control group by related samples nonparametric test to identify impact and patterns in their applying the LPoSMC after the professional development. In addition, we assessed teachers' understanding of scientific model both prior and after the workshop. The result suggests that teachers' understanding of scientific model progresses significantly both on overall scores and four sub-dimensions except one dimension. Wilcoxon test analysis indicates that there is significant difference between the experiment group and the control group both at the total impacts and seven roles of learning progression when evaluating and revising instructional plans.

Implementing STEM Education at a District Level
Tamara Holmlund Nelson, Washington State University, Vancouver
Kristin S. Huggins, Washington State University
ABSTRACT:
Across the U.S., educators are responding to the call to provide opportunities for all students to become proficient in what is commonly called STEM education. There are an increasing number of funded professional learning projects to support this, yet little is known about how educators integrate STEM education across a school district. To study this, we selected two districts who sent teams to a week-long Leadership in STEM Education institute. One team represented a small, rural school district and the other a mid-sized suburban district; both teams developed a STEM implementation plan during this institute. Using case study methods and a sensemaking theoretical framework, we examined the content of teams' plans, interactions amongst the leadership team and others to implement the plan, and the human and materials resources and contextual elements that supported or hindered their implementation.

Each team constructed a common vision for STEM education, although the vision of each was notably different. Team members networked with others at school and district levels and encountered a variety of understandings about and various degrees of willingness to engage in STEM education. Our early findings suggest the importance of distributed leadership, ongoing professional learning, and access to human and material resources.

Learning About Teaching Practices: The Importance of Providing Support Structures in Science Professional Development
Dante Cisterna, University of Missouri
Ibrahim Delen, Usak University
ABSTRACT:
Professional development has been considered as a main strategy to support teacher growth in knowledge and practice. Although there is some agreement about characteristics of well-designed professional development programs, it is not clear how those characteristics and frameworks develop during the professional development and translate into outcomes for teachers and students. In this multiple-case study, we present the professional development experiences of two teachers when learning about teaching practices. We illustrate challenges for experienced teachers, by focusing on the process of learning teaching practices to help students work with scientific evidence and promote students' reflection on their own learning. Our findings suggest that even in well-designed professional development programs, experienced teachers may struggle with its design and organization, so additional and customized structures may be needed for supporting teacher learning. We also suggest some implications for science teacher professional development.

Maker Educators: Encouraging Active, Creative, and Self-Directed Students through Making in School Settings
Amber Simpson, Indiana University
Chad Ratliff, Assistant Director of Instruction, Albemarle County
Adam V. Maltese, Indiana University
ABSTRACT:
There are a growing number of makerspaces emerging in K-12 formal learning environments across the United States. Access to makerspaces in schools, as well as implementing making activities into classrooms, presents a challenging, yet promising approach to transforming STEM education. Yet there are many factors to contend with in these settings including standardized testing and lack of training. In examining how self-identified maker educators discuss their role within a K-12 formal learning environment, attendees will be challenged to consider ways the results can address issues related to pre-service and in-service teacher education reform. More specifically, the findings from this study will serve as an initial effort to begin rethinking teacher education programs, professional development, and interventions for current and prospective science educators.

Mapping a Teacher's Enactment of Engineering Design-based Instruction and Impact on Student Learning
Jeffrey D. Radloff, Purdue University
Brenda M. Capobianco, Purdue University
Jacqueline DeLisi, Education Development Center
Chell Nyquist, Purdue University
Nancy Tyrie, Purdue University
ABSTRACT:
Recent U. S. science standards emphasize the integration of scientific and engineering practices as well as students' learning of core disciplinary concepts with active engagement in doing science. Consequently, science educators must be equipped with the knowledge and skills necessary to teach science using the engineering design process. Equally important is the need to document and characterize how teachers enact these practices and describe how their implementation impacts student learning. In this poster presentation we describe a validated approach to documenting an elementary teacher's implementation of engineering design and further supplement this with evidence of student performance on task-based knowledge assessments. Results demonstrate that students spent the majority of class time in small teams engaged in all phases of the design process while showing significant gains in core disciplinary concepts. Implications suggest that the observation tool provides a useful means of documenting a teacher's enactment of engineering design-based pedagogies.

Retaining New Teachers in High Need Districts: What They Say has Helped
Tyler Wooley-Brown, Boston University/Brookline High
Peter S. Garik, Boston University
Russell Faux, Davis Square Research Associates
Dan Dill, Boston University
Andrew Duffy, Boston University
Bennett Goldberg, Boston University
Mark Greenman, Boston University
ABSTRACT:
Understanding which aspects of beginning secondary science teachers' (BSSTs) pre-service and induction experiences the BSSTs perceive as valuable during their first three years of service is particularly important if we have any hope of retaining those same teachers in our urban and rural high need schools. This qualitative, single-case (embedded) study explores which aspects of the crucial

beginning experiences a group of BSSTs valued most by the end of their second year in the classroom. Study results show that the most valuable experiences included the training that BSSTs received in science teaching methods, equitable classroom management practices for diverse populations, and teaching English Language Learners. Perhaps more important were the interpersonal relationships they cite that they were able to build and maintain with the other members of their cohort. Of particular importance are our findings that strongly suggest that the creation of cohesive cohorts of new teachers can provide highly valued professional, emotional and social peer support during the pre-service and induction years.

Teacher Agency as a Mediator for Professional Identity in Secondary Science Teachers
Gail Richmond, Michigan State University
Kraig A Wray, Michigan State University
ABSTRACT:
One of the most significant issues facing science education is the departure of teachers from the profession in large numbers. Attrition is particularly problematic for those teachers in their first few years of teaching. In this study, we investigated the challenges novice teachers faced and factors that supported or constrained action related to these challenges. Using a framework that places teacher agency and professional identity at its center, we investigated how these constructs might be used to explain what candidates perceive as challenges and how they respond to these challenges. We present cases of three secondary science teachers in high-needs contexts. The values of the teachers remained stable as they transitioned from intern to full-time teacher, especially when in a context that supported these values. When placed in a school that challenged a teacher's values, the context restricted their ability to act in a way that supported agentic behavior. We concluded that the opportunity to develop agency through successful action supports the development of professional identity. This may establish the groundwork on which research on the resilience to endure in challenging teaching contexts is built.

Strand 9: Reflective Practice
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

The Impact of STEM Professionals as Teachers: An Action Research Project
Brandon Rodriguez, NASA Jet Propulsion Lab
ABSTRACT:
The goal of this work is to assess student perception to STEM careers when in the presence of scientists in the classroom. Our school has several doctorate level scientists who have become full time teachers and who design content based on their careers as scientists. I was interested in measuring the impact of the teachers who infuse their curriculum with genuine experience and content relevance, explored via student career aspirations and descriptions of their science coursework. This is of particular interest considering our diverse student demographic, being that our doctoral scientists also reflect underrepresented minorities in STEM. This is a target group not just for teachers, but also for the private research sector, which is also being impacted by lack of scientifically literate and creative scientists in the hiring pipeline, capable to tackling today's complex R&D issues.

Strand 10: Curriculum, Evaluation, and Assessment
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

The Learning Loss Effect in Genetics: What Ideas Do Students Retain or Lose After Instruction?
Amber Todd, Wright State University
William L. Romine, Wright State University
Michele Miller, Wright State University
ABSTRACT:
Modern genetics is a relatively new domain but it is increasingly important for students to have a firm grasp on the content since genetically modified organisms, genetic screenings, and stem cell therapies are becoming more commonplace. In a previous study, we used the Learning Progression-based Assessment of Modern Genetics to assess high school students' knowledge of genetics concepts after an intensive ~23 calendar week long genetics instructional period. Given that this type of instruction is unique and may represent a "best case scenario," we are now investigating how students' knowledge of genetics changes after instruction (i.e. learning loss effect). Using multi-level growth modeling, we find that overall student scores were significantly decreased a year after instruction ended compared to their scores immediately after instruction ended. Interestingly, there was no significant difference in scores a year after instruction ended compared to scores immediately after instruction for 10 of 12 genetics concepts. Two concepts showed a significant reduction in student scores: details of meiosis, and how genetics concepts are related to each other. Our analysis demonstrates students tend to retain mechanistic explanations in genetics while forgetting memorized details.

An Innovative Formative Assessment Cycle: Formative Assessment from a Sociocultural Perspective
Nilay Muslu, University of Missouri, Columbia
ABSTRACT:

Assessment is an inseparable part of learning. Understanding the importance of the social aspects of learning is increased by research in education. As use of sociocultural learning theory has increased research has shifted to align with it. However most of the studies use it during analysis and not in classroom applications. The purpose of this paper is to examine the relationship between assessment and sociocultural learning theory in order to apply it in classroom assessment. Based on literature key elements and characteristics of sociocultural theory are generated. The relationship between its characteristics and assessment are discussed. Lastly a new model of a formative assessment cycle is developed based upon sociocultural learning theory. This model provides a new perspective to understand the formative assessment process.

Assessing and Understanding Student Engagement in Design-based Science in Small Group Work: Two Methodological Perspectives
Miancheng Guo, University of Massachusetts, Amherst
Elizabeth McEneaney, University of Massachusetts, Amherst
Martina Nieswandt, University of Massachusetts, Amherst
ABSTRACT:
Recently, video data has become a more and more popular means for teachers and researchers to capture interactions in classrooms. However, there has been little research literature on analyzing video data using mixed methods approaches. This paper introduces a mixed methods video data analysis case in which high school students' academic engagement in a design-based science (DBS) activity is assessed and deeply understood through the combination of a quantitative data analysis technique named sequence analysis and a qualitative data analysis technique named elaborated running records (ERRs). Thus, this paper not only introduces an innovative method of video data analysis, but also presents an alternative form of assessment of student academic engagement.

Students' Abilities to Critique Scientific Evidence when Reading and Writing Arguments
Amanda Knight-Bardsley, Egan Maritime Institute
Katherine L. McNeill, Boston College
ABSTRACT:
Argumentation has become a goal within recent policy documents, including the Next Generation Science Standards, which, in turn, presents a need for comprehensive, effective, and scalable assessments. This study uses assessments that measure students' abilities to critique scientific evidence, which is measured in terms of the form of justification and the support of empirical evidence, when reading and writing scientific arguments. Cognitive interviews were conducted with a subset of the students to explore the criteria they used to critique scientific evidence. The research investigates students' abilities to critique scientific evidence and the criteria they use to do so as well as whether the four constructs represented four separate abilities. Findings suggest that when writing scientific arguments, most students constructed a justified claim, but struggled to justify their claims with empirical evidence. In comparison, when reading scientific arguments, students had trouble locating a justification when it was not empirical data. Moreover, findings from the cognitive interviews suggest that students with more specific criteria tended to have more knowledge of the construct. Lastly, dimensional analyses suggest that these may not be four distinct constructs, which has important implications for curriculum development and instructional practice.

Science Education For All: Addressing Issues of Equity and Social Justice Through SSI
Tara M. Nkrumah, University of South Florida
Selene Y. Willis, University of South Florida
ABSTRACT:
In this positional paper, we argue that given the objective of a Socioscientific Issues (SSI) curriculum to produce scientifically functional literate citizens through moral and ethical decision-making, equity and social justice cannot be overlooked in SSI curriculum. Through our literature review analysis, we explore the question, "To what extent is equity and social justice (SJ) expressed in the SSI curricula?" The theoretical frameworks used to inform this investigation include SSI and social justice. The findings reveal that in research of SSI curricula neither equity nor SJ are explicitly addressed, despite its emphasis on ethical and moral reasoning. Therefore, we render a framework to develop science curriculum that serves to raise students' social consciousness about issues of equity and justice. This framework extends SSI to include an emphasis on the social significance of scientific issues for various social groups. The proposed science education aims to prepare students to think scientifically and ethically as well as engage in social action or activism.

A Progression and Bundling Model for Developing Integrated, Socially-relevant STEM Curriculum Aligned with the NGSS
Brenda G. Bergman, Michigan Tech University
Stephanie Tubman, Michigan Tech University
Emily Gochis, Michigan Technological University
Jacqueline E. Huntoon, Michigan Technological University
ABSTRACT:
As districts around the country increasingly adopt the Next Generation Science Standards, curricula aligned with these standards are needed. Progression models provide a foundation for developing curricular units that sequentially guide students through coherent learning within a grade band. Various models are possible for a given set of standards, and the selected model must address the goals of the education initiative. Here we present and explain a progression model and bundling of the 59 performance expectations for the middle grade band. This model provides the basis for developing units around unit challenges, through which students apply multiple

STEM disciplines to address an issue of societal relevance while coherently learning STEM content and Practices. We explain two key mechanisms for achieving integration and coherence: primary and supporting sub-components of performance expectations, and unifying crosscutting concepts. The unit challenge progression model contributes to the field of science education by providing a practical tool for curriculum developers and a platform for continued research in integrated STEM education.

An Assessment Instrument for Systems Thinking in Science and Engineering Education
Rea Lavi, Technion- Israeli Institute of Technology
Yehudit Judy Dori, Technion-Israel Institute of Technology
Niva Wengrowicz, Technion
Dov Dori, Technion
ABSTRACT:
Demand for systems thinking—holistic comprehension of systems—is rising. We conducted a literature review of science, technology, engineering, and mathematics (STEM) education research and then developed an instrument with 10 criteria for assessing systems thinking in science and engineering, based on Object-Process Methodology conceptual system models. We present findings from our initial assessment of its validity and reliability. Teams comprised of 120 engineering students created 25 OPM models of commercial Web-based systems, which we scored using our criteria. For internal consistency, we calculated Pearson correlations within criteria and between raters, and conducted a two-way repeated measures test within criteria and between raters. Assessments indicated medium-to-high interrater reliability. For construct validity, confirmatory factor analysis of scores indicated a good fit between the model and observed data. While initial findings were informative, more models should be added to the assessment, and further assessments are required. The instrument we are developing could eventually be used for both summative and formative assessment in science and engineering courses, and potentially serve STEM researchers in studying how people use models for systems thinking. Our study may create a common language with regards to systems thinking, enabling dialogue within the science and engineering education communities.

An Examination of Three Approaches to Engineering Integration
Selcen Guzey, Purdue University
Elizabeth A. Ring, University of Minnesota
Maurina L. Aranda, Purdue University
Tamara J. Moore, Purdue University
ABSTRACT:
The new science education reform documents call for integration of engineering into K-12 science classes. This paper presents a research study that evaluates the effects of three different engineering integration approaches on student learning and interest. A middle school life science teacher and 330 6th grade students participated in the study. Content assessments and interest survey were administered before and after the implementation of three design-based science curriculum units. Furthermore, over 45 classroom observations were conducted and classroom instruction was videotaped. The qualitative data demonstrated the similarities and differences among three approaches to engineering integration, namely, add on, implicit, and explicit. Single level regression results for science and engineering outcomes favored explicit integration of engineering. Practical implications will be discussed.

Assessing Vision II Literacy with Socio-scientific Issues: A Quantitative Assessment of Socio-scientific Reasoning
William L. Romine, Wright State University
Troy Sadler, University of Missouri
Andrew T. Kinslow, University of Missouri
ABSTRACT:
We describe the development and validation of the Quantitative Assessment of Socio-scientific Reasoning (QuASSR) in a college context. The QuASSR contains 10 polytomous, two-tiered items crossed between 2 scenarios, and is based on theory suggesting a four-pronged structure for SSR (complexity, perspective taking, inquiry, and skepticism). We found that the 4 sub-constructs represent a one-dimensional progression of ideas, and that SSR is largely independent of declarative knowledge. We discovered small inconsistencies in item functioning between scenarios in the areas of complexity and perspective-taking, but determined that resulting biases sat well within the uncertainty in students' measures. Use of a single scenario is sufficient to produce a measurement reliability of 0.7. Given the time it takes for students to complete a scenario, we consider a 3-scenario QuASSR, and its accompanying measurement precision of 0.85, to be the practical upper precision limit of the QuASSR when used in experimental contexts. No significant change in SSR due to the SSI-based intervention was found. Our data suggest that as a cognitive construct underpinned by political, moral, and ethical ideologies around SSI, successful efforts to facilitate growth must target SSR as a central focus upon which more basic content knowledge is contextualized.

Exploring Teacher Design Teams Endeavors while Creating an Elementary-focused STEM-Integrated Curriculum
Gillian Roehrig, University of Minnesota
Justin McFadden, University of Louisville
ABSTRACT:
This study presents two teacher design teams (TDTs) during a professional development experience centered on the development of a STEM integrated curriculum. The acknowledgement of teachers during reform efforts has emerged because they play an important

role in adapting curriculum resources for localized contexts. Remillard¹s (2005) teacher-curriculum participatory relationship provided a framework for exploring TDTs because it acknowledges the interactive relationship a teacher engages in when selecting and modifying curriculum. Utilizing a case study research design, participant conversations were recorded for 12 days. Constructed grounded theory and selective coding yielded two empirical assertions. First, when teachers were asked to assimilate their personal resources with the expertise needed to be a curriculum designer, it was difficult for them to separate their intuitions as classroom teachers from the task at hand. Second, Remillard¹s (2005) teacher-curriculum participatory relationship fully engaged teachers during curriculum design, which influenced how they allocated resources to achieve their goals. Finally, curriculum as a cultural artifact has the power to afford and constrain human activity. Therefore, involving teachers during the inauguration of curriculum reform adds to it the additional responsibility of giving them a voice about what any educational reform should or will look like.

Strand 11: Cultural, Social, and Gender Issues
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Maker Identity: Profiles and Perspectives of Latina Young Women in a Maker Project
Jasmine Kyle McBeath, University of California, Santa Barbara
Javier Pulgar, University of California, Santa Barbara
Richard P. Duran, University of California, Santa Barbara
ABSTRACT:
Building a strong "STEM identity" in science classrooms is essential for improving equity in STEM fields. However, often ignored are ways in which informal project-based learning in out of school settings can promote this goal. The Maker Movement offers girls such a route responsive to their social motivation to collaborate and learn with their peers. However, there is virtually no relevant research with Latinas from low income immigrant backgrounds. We employed Cultural Historical Activity Theory to examine the complex activity system of an afterschool Maker project that blended science learning with creation of a fun-game electronic bean bag project with artistic elements. We traced the joint problem-solving, and dialogue of 7 Latina adolescents in designing and implementing of the interactive bean bag game for a community faire. We found that youths were very adept at analyzing STEM vs. non-STEM artistic expertise among team members and in organizing project role identities accordingly. Interestingly, girls who identified as being more expert in artistic project roles also manifested greater willingness to adopt STEM related roles by the end of the project as shown by science questionnaire results, interviews, and willingness to explain to others more technical aspects of the bean bag project.

The Experiences of Gay Men in STEM Majors and Workplaces: A Critical Review
David P. Steele, University of Georgia
ABSTRACT:
Sexual minority students face oppression and homophobia through societal norms that can be expressed both implicitly and explicitly. Even though attitudes towards, and acceptance of, gay men have improved, these individuals continue to find themselves subject to gendered expectations on college campuses as well as in the workplace. The purpose of this literature review was to explore and critique the literature detailing the experience of gay men with heterosexism and heteronormativity in STEM classes, majors, and careers. Due the underwhelming number of previous studies, the review was expanded to include these experiences of gay men regardless of field. The results revealed that while there has been a general improvement of attitudes towards these individuals, along with an increased visibility and inclusive guidelines in place, gay men still encountered feelings of isolation and of cumulative disadvantage. They also reported feeling the need to develop coping strategies such as covering their sexuality or making themselves indispensable to ensure employment. These findings might offer an understanding as to how we as teacher educators make science more gender neutral and therefore more accessible to all.

Cross-cultural Comparison between the Function of Social Support through Task Value in Students' Science Learning
Chen-Lung Wang, National Central University
Pey-Yan Liou, National Central University
ABSTRACT:
This study aims to test a theoretical structural model, the Expectancy-Value Theory (EVT), which investigates the relationships among social support, task value, and science achievement across cultures. To conduct a cross-cultural comparison study, the Trends in Mathematics and Science study 2011 eighth-grade data for the U.S. and Taiwan were examined. Path analysis was used to investigate the relationships in two different cultural and social contexts. The results showed that the theoretical structural model was confirmed in both countries, indicating that intrinsic and utility value yielded positively direct effects on science achievement. Additionally, the positive mediating role of both the intrinsic and utility value appeared in the relationship between social support and science achievement in both the U.S. and Taiwan. This current study also found differences between the U.S. and Taiwan. First, the positive total effect of parental and teacher value on science achievement in Taiwan was much higher than that in the U.S. Second, the total effect of utility value on science achievement in Taiwan was twice that in the U.S. This confirms that the magnitudes among these variables based on EVT appear to differ due to cultural differences.

Strand 12: Educational Technology
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Using Unmanned Aerial Systems to Bring STEM Field Experiences to the Classroom
Pavlo D. Antonenko, University of Florida
Ivan Mutis, Illinois Institute of Technology
ABSTRACT:
This study was designed to advance our understanding of Unmanned Aerial System (UAS) technology uses in STEM education. Specifically, we explored the promise of UASs to advance Construction Engineering and Management (CEM) education and bring remote job-site environments into the classroom. Five themes that emerged during inductive data analysis centered on the benefits of UAS technology enhance processing of complex spatial and temporal information. Participants expressed that aerial visualizations can enhance the processing of complex visuo-spatial information and eliminate split-attention effects through the integration of all relevant visual information into one view. This affordance gives a unique perspective to the observer to facilitate the simultaneous visualization and integration of physical and social factors in in-situ CEM contexts, rather than studying an abstract case from a textbook with static images and text. UAS technology can bridge the gap between classroom learning and field observations, especially given that many authentic field sites are dangerous and difficult to observe by students. This study provides important implications for teaching and research that would be of interest to NARST members as they consider strategies for improving the design of traditional, blended, and online learning environments that make use of virtual field experiences.

The Teachers' Evaluation of a PhET Simulation: A Designer's Perspective vs. a Learner's Perspective
Xiaoyang G. Gong, University of Maryland
ABSTRACT:
Technology is regarded as one of the most promising approaches to transform teaching and learning in science classrooms. However, previous studies reported that some science teachers are unconfident or unwilling to integrate a technology in classroom instruction. In this paper, I used a particular technology tool-PhET simulation- as the example and found that (1) teachers evaluated the simulation module from different perspectives: a designer's perspective and a learner's perspective; (2)the differences in teachers' perspectives shaped their pedagogical practices of integration. Therefore, more communication is recommended to bridge the knowledge gap between simulation designers and classroom teachers.

To Use AR (Augmented Reality) or not to use AR in Formative Assessment? A Comparison
Kaushal Kumar Bhagat, Beijing Normal University
Wei-Kai Liou, National Taiwan Normal University
Chun-Yen Chang, National Taiwan Normal University
ABSTRACT:
The aim of this study was to examine the effectiveness of using Augmented Reality (AR)-based formative assessment for improving students' learning achievement. A total of 70 students of Grade 4 were selected from an elementary school located in Taiwan. The experimental group (35) underwent AR-based formative assessment using iPad whereas the control group (35) followed the traditional method of formative assessment. One-way Analysis of Co-variance was utilized to analyze the data obtained. The results clearly indicated that using AR-based formative assessment can improve students' learning performance effectively compared to traditional methods. It is highly recommended to integrate AR for formative assessment purpose in the mainstream of teaching and learning process.

Using Field and Online Technologies to Learn Watershed Modeling
Nanette Dietrich, Millersville University
Carolyn Staudt, Concord Consortium
Steven Kerlin, Northern Kentucky University
ABSTRACT:
Teaching Environmental Sustainability - Model My Watershed (MMW) curricula and toolset (NSF ITEST DRL - 0929639 DRK-12 DRL -1417722, 1417527, 1418133) situates student learning in the exploration and evaluation of the conditions of their local watershed using probe-ware and a scientifically valid online watershed modeling application. Students analyze real data from national databases embedded into the MMW GIS platform, collect data from their schoolyard using digital probes linked to tablets or smartphones, and create and model changes in land cover and conservation practices in the inquiry-based activities. The study indicates that a place-based technology enhanced watershed modeling curriculum is an effective tool for increasing students' understanding of watersheds, encouraging personal environmental action and promoting career interest.

Using Electronic Textiles to Train Teachers to Build Models While Teaching Core Content
Kristin Seattle, Utah State University
Colby Tofel-Grehl, Utah State University
Vicki Allan, Utah State University
ABSTRACT:

In this paper, we present an electronic textiles project called the "bracelet hack" that is intended to facilitate the introduction of computer programing activities into core science classrooms. Teachers use electronic textiles, or sewable circuits, to teach the content around circuits and electricity while building working models for teaching NGSS standards. The project's design significantly decreases the costs and amount of classroom time that must be spent on the construction aspects of the project while still engaging students in design challenges. To test our hypothesis that the bracelet hack would allow just as much introduction to coding as more complicated, sewn LilyPad Arduino projects, while allowing teachers to teach content topics, we introduced the bracelet hack in the context of a professional development workshop for middle school science teachers. We analyzed teachers' audio recorded interactions while completing the bracelet hack and found that teachers were able to learn computational concepts, practices, and perspectives through the activity.

Strand 13: History, Philosophy, and Sociology of Science
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Science Teachers' Conceptions about Technology and Engineering in the Scientific Endeavor
Allison Antink-Meyer, Illinois State University
Daniel Z. Meyer, Illinois College
ABSTRACT:
Technology, engineering and science are interdependent to a great degree in both technical research settings and in society in general. Their significant overlap is underplayed in K-12 settings where curricular structures historically de-emphasize the interdisciplinarity of science disciplines and where engineering and technology education are seldom explicitly provided within science departments. Engineering and technology education has been described as a means to provide context for science learning (Erekson & Custer, 2008). The inclusion of engineering practices within the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013) has promoted discussion about engineering in science curricula, science teachers' understandings about the distinctions between science and engineering (Authors, 2016; Cunningham & Carlsen, 2014), and their knowledge of engineering pedagogy (Hynes, 2012). The extent to which science teachers have the conceptual knowledge needed for technological and engineering education has been shown to likely be modest (NAE & NRC, 2009), however. The purpose of this study was to examine how science teachers conceive of the overlap and distinctions between the practice of science, engineering, and technology.

The Influence of an Authentic Engineering Design Experience on Elementary Teachers' Engineering Teaching Efficacy Beliefs
Hasan Deniz, University of Nevada, Las Vegas
Ezgi Yesilyurt, University of Nevada, Las Vegas
Erdogan Kaya, University of Nevada, Las Vegas
ABSTRACT:
This study assessed the influence of an authentic engineering design experience on elementary teachers' engineering teaching efficacy beliefs. Participants were 30 elementary teachers from different schools in a large urban school district in southwestern United States. We used a modified version of Science Teaching Efficacy Beliefs Instrument Version A (STEBI-A) (Enochs and Riggs, 1990) to measure participants' engineering teaching efficacy beliefs. Our results indicated that our participants improved their personal engineering teaching efficacy (PETE) beliefs but they did not improve their engineering teaching outcome expectancy (ETOE) beliefs as a result of our 3-day professional development program. These results suggest that teachers might need more long-term professional development to develop their ETOE beliefs.

The Retention of STEM Teachers in High Need Schools: Could Gender Socialization Have a Role?
Stacy Olitsky, Saint Joseph's University
ABSTRACT:
Historically marginalized groups of students are less likely than middle-class White students to be taught by qualified science and math teachers partly due to teacher turnover in high-need urban schools. Several studies have suggested that women have even higher attrition rates from teaching in high-need schools than men. As of yet, there has not been substantial research to investigate why this might be the case. This paper draws on data from a qualitative study of STEM teachers who are part of the NOYCE program and had received scholarships in return for commitments to teach in high need schools for 2-4 years. The paper addresses the following questions: 1) How do teachers' internal conversations influence identity development and decision-making about retention? 2) How might gender play a role in shaping identity development via the internal conversation? The results of this small-scale study raise the issue that self-talk that focuses on "re-living" and "mulling-over" can detract from the development of STEM teacher identities in high need schools and could therefore contribute to turnover. While the relationship with gender is only suggestive, patterns in self-talk around difficulties with instruction could be connected to socialization related to fixed ability vs. effort.

Strand 14: Environmental Education
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Intersection between Global and Self-reported Community-based Environmental Concerns
Leslie Neitzer, Southern Illinois University
Vivien M. Chabalengula, University of Virginia
Frackson Mumba, University of Virginia
ABSTRACT:
This study examined 84 American high school students' concerns towards global environmental issues and their self-reported community-based environmental issues emanating from their local environments. Data were collected using the Likert scale instrument consisting of global environmental issues, and an open-ended survey question requiring students to indicate the environmental concerns emanating from their own local environments. Results revealed the following: (a) Students were very concerned about the following global issues in this descending order: Hazardous wastes; industrial pollution; global warming; poor drinking water; automobile emissions; burning of fossil fuels; and production of cement/concrete. (b) Students enrolled in an ecology course were more concerned than those not in ecology courses. This finding is similar to Pe'er et al (2007), who found that students majoring in environmental science were more knowledgeable and had more positive attitudes. (c) Students living in urban settings were more concerned than those dwelling in rural areas. (d) Students' most common self-reported community-based environmental concerns surrounding their communities included littering/trash, air/industrial pollution, hydrofracking, automobile pollution, poor drinking water, and building materials; and intersected with the global issues. (e) One of the localized environmental concerns cited by the students was hydrofracking, which is commonplace in that region of the Midwestern United States. The implications of these results to science teaching/learning and curriculum design are discussed. kylew 0 0 2016-06-30T15:48:00Z 2016-07-05T14:14:00Z 1 253 1431 UVa 42 23 1661 14.0 Print 0 false false false EN-US JA X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin-top:0in; mso-para-margin-right:0in; mso-para-margin-bottom:10.0pt; mso-para-margin-left:0in; line-height:115%; mso-pagination:widow-orphan; font-size:11.0pt; font-family:Calibri; mso-ascii-font-family:Calibri; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Calibri; mso-hansi-theme-font:minor-latin;}
Key Words: Environmental concerns, Global, Community-based concerns

Middle and Secondary Science Teachers' Knowledge and Beliefs about Climate Change
Rana Khalidi, University of Houston
ABSTRACT:
Science teachers' knowledge and beliefs about climate change can impact their professions as teachers and affect their instruction in the classroom. A survey instrument was used to investigate middle and secondary science teachers' knowledge and beliefs about climate change. The study assessed teachers' knowledge about climate change. It also examined the extent to which they believe that climate change is happening and extent to which they believe it can be remediated by human activity. Forty-three middle and secondary school science teachers from an urban public school district, located in the Southeastern part of Texas, completed an online survey instrument. Study findings indicate that the majority of participating teachers believed that climate change is happening. However, many still viewed it as controversial in terms of what is causing it and whether there is scientific consensus about it. Results also suggest that teachers were not entirely confident in their knowledge to teach about climate change effectively. Findings highlight the need for developing more effective professional development programs and teacher education programs that can prepare better qualified science teachers and advance the quality of climate change education.

Moving Students towards Climate Consensus (slightly) through Argumentation
Barry Golden, University of Tennessee
ABSTRACT:
While climate science remains controversial in some quarters, the scientific community has long reached a point of consensus about both the reality of climatic changes, including net warming, AND the causal nature of current warming being primarily due to anthropogenic fossil fuel burning. This research set out to use scientific argumentation as a means by which to promote student learning about these elements of current consensus. We created a two week unit which included two separate argumentation-focused sessions. Interviews before and after the unit were conducted to learn about the conceptual changes undergone by these students. We argue that the data indicate that conceptual changes were seen by virtue of a shift in how these students talked about climate change science, and by what sorts of evidence tended to be invoked in accordance with their arguments. Also, we found evidence of some barriers to conceptual change, including that some students tend to view climate change as a topic which is indistinguishable from many other environmental issues, including oceanic litter and dolphins caught in tuna nets, etc. The research strongly implies a need to help students develop some ontological categories to better appropriately situate their understandings.

Socio-scientific Reasoning in a High School Field Ecology SSI Course
Andrew T. Kinslow, University of Missouri
Troy D. Sadler, University of Missouri
Hai T. Nguyen, University of Missouri, Columbia
ABSTRACT:
This study investigates the impact of a field ecology course engineered around an empirically based socio-scientific issues (SSI) instructional framework on high school student's critical thinking and reasoning skills. Nineteen students participated in a six-week

summer field ecology class in which they were engaged with ornithology and water quality research projects embedded within SSI instruction. The impact on student's socio-scientific reasoning (SSR) was examined through mixed methodology. In conjunction with learning gains around fundamental ecology and water chemistry, statistically significant improvements were found in three of the four SSR competencies from the pre to post-class assessments. Qualitative analysis of student's course work indicates the skepticism SSR competency is more abstract for high school students and often interwoven with other SSR components.

Teaching Environmental Education: Conceptual Analysis
Paulina Grino, University of Arizona
ABSTRACT:
This conceptual analysis reviews five environmental education paradigms, Outdoor Education, Earth Education, Education for Sustainable Development, Ecojustice, and Ecoliteracy, as these are the main paradigms in the literature that reports about teaching and environmental education. The purpose is to study philosophies, pedagogical approaches, and limitations of each paradigm to provide a general view of the field and to attempt to conceptualize and characterize the practice of teaching environmental education. Education for Sustainable Development is a broader field developed by a global organization; on the contrary outdoor education has been developed from practice as well as earth education. Conclusions from the analysis indicate that the inclusion and access of diverse students to environmental learning experiences are limited due the origin and history of each paradigm. In this regard, Ecojustice and Ecoliteracy seem to offer more pedagogical opportunities to include minorities into learning experiences developed within these paradigms. This conceptual analysis offers an overview of the field in addition to presents teaching limitations for each paradigm.

How Consistent are the Goals of Environmental Science Education Across Research and Policy Documents?
Margaretann G. Connell, Illinois Institute of Technology
Norman G. Lederman, Illinois Institute of Technology
Judith S. Lederman, Illinois Institute of Technology
ABSTRACT:
Abstract Despite the vast research conducted in the field of environmental education (EE), there is still concern of the convergence between science and environmental education (Wals et al., 2014). It is apparent that the field has been saturated with ideology instead of scientific knowledge as the foundational goal of instruction and that there are two opposing visions for EE, whether the goal is to teach science or as an advocacy for stewardship. The purpose of this study was to investigate the consistency of the goals of environmental science education(ESE) across research and policy documents. To achieve this, the researcher conducted a qualitative content analysis of research and policy documents. Data sources consisted of scholarly research articles (n=118) from 1969- 2015; published books (n=4); and policy documents (n=11). The results revealed that historical documents that laid the foundation for the goals of EE are still current in classroom and experiential experience curricular planning. Yet, there are still no consensus goals for ESE. Based on the results, the researcher hopes this research will contribute to the awareness of the NARST community as, 'a call to action' to develop cohesive goals for (ESE) within or apart from the framework of EE.

Strand 15: Policy
Poster Session B
4:15-5:15pm, Hyatt Texas Ballroom A, B, and C

Policy Messaging and Local Contexts: Early Implementation Efforts of the Next Generation Science Standards
Tina Cheuk, Stanford University
ABSTRACT:
Building on research that has examined policy dimension that considers the interactions between behaviorial change for educators, contextual influences, and policy messaging, this work aims to illuminate how these interactions are contributing to science teachers' knowledge, beliefs, and attitudes toward Next Generation Science Standards (NGSS) reform efforts. Pragmatically speaking, this work illuminates how a mid-sized urban district are building their professional learning culture, structural supports, and instructional tools during this important transitional period prior to full NGSS implementation. What teachers know, believe, and value for their subject areas can shape how these sets of policies are interpreted and adapted in classrooms. Additionally, the district and the school departmental contexts serve as critical drivers that shape teachers' decision-making in and across these nested communities. Lastly, how teachers receive the various policy signals during this transition time can influence what changes, if any, will happen within the instructional core. It is the interactions of these three dimensions that will shape how the policy will be translated, understood, and then adapted by the classroom teacher, and ultimately, experienced by the students.

Science Teacher and Administrator Perspectives of Teacher Evaluation Systems
Jessica A. Mintz, Stony Brook University
Angela M. Kelly, Stony Brook University
ABSTRACT:
The goal of this study is to investigate the current Annual Professional Performance Review (APPR) system for science teachers in New York from the perspective of science teachers and administrators. Science teachers are unique among high school educators in that they specialize in sub-disciplines (biology, chemistry, physics, or Earth science), and in the case of New York State, their students

must take high stakes science exams at the culmination of each course. Thus, student performance has consequential validity in the rating system, despite the fact that there are no adjustments for variations in student preparation and other characteristics. In order to make policy recommendations regarding evaluation practices, science teachers and administrators were interviewed to examine their perceptions of the current process. The researchers interviewed 5 science teacher/administrator pairs from select school districts with varied ranges of experience and content area certification. The study investigated the unintended consequences the teachers and administrators experienced using the performance rating system. Insights from the initial evaluation of these data are encouraging for making recommendations for revamping science teacher evaluation policy. With science teacher and administrator input and support, designing a comprehensive system of evaluation is achievable and desirable to maximize buy-in among key stakeholders.

Plenary Session #2
Theme: Challenges in Learning Science Concepts
8:45am – 10:15am, Hyatt Texas Ballroom A, B, and C
Presider: Mei-Hung Chiu, National Taiwan Normal University

Presenter:
Michelene (Micki) Chi, Dorothy Bray Endowed Professor of Science and Teaching, Division of Educational Leadership and Innovation,
Mary Lou Fulton Teachers College, Arizona State University
Title: Teaching Emergence: An Attempt at Differentiating Science Concepts of Processes
ABSTRACT
The robustness of many misconceptions about science concepts has been explained by the ontological commitment in students' thinking to an alternative category of processes. That is, many science concepts of processes require an emergent kind of causal explanation whereas students' misconceptions provide a sequential kind of causal explanation. In order to teach students to be able to give a correct causal explanation, we need to teach students an understanding of emergent processes. We are developing a module that attempts to help students differentiate emergent from sequential processes by contrasting everyday emergent and sequential processes. Students reveal difficulty in understanding the macro-level patterns of processes.

Presenter:
Stella Vosniadou, Strategic Professor, School of Education, Flinders University, Australia
Title: The Co-existence of Intuitive and Scientific Understandings: Implications for the Design of Curricula and Instruction
ABSTRACT:
The realization that students are not 'tabula rasa' when exposed to science concepts but have alternative conceptions (preconceptions, misconceptions) that may inhibit science learning, was one of the important outcomes of research in the 80's. Since then, cognitive science research has succeeded in describing the many kinds of conceptual changes that are necessary as individuals move from intuitive beliefs to learning science, mathematics, medicine, economics, etc. Throughout these years it has been implicitly assumed that in the process of conceptual change scientific explanations and theories replace intuitive understandings, particularly in the minds of experts. Although some researchers had suggested that this may not be the case some time ago, it is only recently that a body of evidence started to be accumulated demonstrating the co-existence of intuitive conceptions and scientific explanations in a number of different knowledge domains (physics, biology, medicine, psychology, mathematics), different cultures (American, European, African, indigenous populations), and using different methodologies (interviews, questionnaires, reaction time studies, neuroimaging). In this presentation I will discuss some of this evidence and will draw its implications for the design of curricula and instruction.

Concurrent Session #7
10:30am – 12:00pm

Administrative Sponsored Session
Admin Symposium: NSTA's Annual Research Worth Reading Recognition
10:30am-12:00pm, Hyatt Presidio ABC
Presenters:
Deborah L. Hanuscin, University of Missouri, Columbia
Julie C. Brown, University of Minnesota
ABSTRACT:
Each year, NSTA recognizes research studies that have the greatest value for its over 55,000 members in its 'Research Worth Reading' list. Come hear from authors whose work was selected from the 2016 issues of JRST for this honor, and learn more about how NSTA can help your research reach practitioner audiences.

Equity and Ethics Committee Sponsored Session
Admin Symposium: Addressing the Challenges of Science Teaching and Learning in a Glocal Context: Informing Practices in Equity and Ethics
10:30am-12:00pm, Hyatt Republic ABC
Presider: Miri Barak, Israel Institute of Technology
Presenters:
Yehudit Judy Dori, Israel Institute of Technology, Israel
Marcelle Siegel, University of Missouri, USA
Peter A. Okebukola, Lagos State University, Nigeria

Sonya Martin, Seoul National University, Republic of Korea
Alejandro Gallard, Georgia Southern University, USA

ABSTRACT:
Currently, there are numerous challenges to science teaching both on a national and global level. As highlighted in the 2011 Special Issue of the Journal of Research in Science Teaching it is critical to promote scientific literacy for children across the world. Science teaching and learning does not occur in a vacuum and the context of how children experience science across the world on a local levels and within their own communities has implications on a global level. Moreover, there are many challenges to science teaching and it is essential to emphasize the need for all science communities (e.g. science educators, policymakers, teachers, researchers) to share best practices in science teaching and learning that bridge global science and local science. The Equity and Ethics Committee Sponsored Symposium proposes a panel designed to share challenges and solutions to bridging global and local science while promoting sustainability. Panel members will facilitate small break-out interactive sessions and a moderator will conclude the symposium with an overview and recommendations for "next steps".

Strand 1: Science Learning, Understanding and Conceptual Change
Innovative Approaches to Science Teaching and Learning
10:30am-12:00pm, HBG Convention Center 006D
Presider: Steven Mcgee, Northwestern University

Attraction Versus Repulsion, or Attraction and Repulsion? Learning about Chemical Bonding with the ELI-Chem Simulation
Asnat Zohar, University of Haifa
Sharona T. Levy, University of Haifa
ABSTRACT:
This work seeks to solve one of the basic problems in chemistry learning: understanding the chemical bond as dynamic equilibrium between attraction and repulsion forces. This abstract topic is difficult to grasp as there are no examples from everyday life of both attraction and repulsion happening simultaneously. Our theoretical framework is based on embodied cognition theory by relating conceptual learning to intuition development through bodily experiences. We designed the ELI-Chem environment as an Embodied Learning Interactive simulation that enables interaction with atoms while observing the resulting attraction- repulsion forces and energy. The study uses qualitative methods with 14 high-school chemistry students in a pretest-intervention-posttest design, capturing students' gestures and articulations. Our findings indicate a shift from a naïve perception of bonding to a more scientific understanding. From an explanation based on the 'octet rule' depicting the atoms as static "touching" balls, students turn to consider the role of repulsion forces between bonding atoms and the dynamic balance between attraction and repulsion forces. Learning with ELI-Chem overcomes two known persistent hurdles: (1) chemical bonds result from attractive and repulsive electrostatic forces; (2) a chemical bond is most stable when attractive and repulsive forces are equal and energy is minimal.

Integrating the Arts into Science Teaching and Learning
Katie Green, North Carolina State University
Kathy Cabe Trundle, North Carolina State University
Maria Shaheen, Primrose Schools
ABSTRACT:
The term STEAM is often used when discussing the importance of including the arts in teaching and learning about science, technology, engineering and math. However, empirical support on integrating the arts into science teaching and learning is relatively recent. This literature review examined the potential benefits of integrating the arts into science instruction as well as the obstacles that might impede effective implementation of the arts into science teaching and learning. An analysis of 67 relevant articles showed that integrating the arts into science provided benefits to both teachers and learners. Obstacles included identifying opportunities for creativity in the science classroom as well as time and training needed. According the the empirical studies detailed in this literature review, integrating the arts into science teaching and learning can help students ranging from preschool to high school become more scientifically literate and increase interest in science education.

Learning Progression Research: Toward Coherence in Teaching and Learning of Science
Hui Jin, Educational Testing Service
Jamie N. Mikeska, Educational Testing Service
Hayat Hokayem, Texas Christian University
Elia Mavronikolas, Educational Testing Service
ABSTRACT:
We conducted a systematic review on how the learning progression (LP) approach enhances the coherence in science education systems. We examined the historical development of the learning progression approach and developed a conceptual framework to guide the review. The framework emphasizes that LPs, which capture the developmental trends in the logical, cognitive, and epistemological aspects, should provide guidance to ensure the horizontal coherence—the alignment among curriculum, instruction; and the vertical coherence—the alignment between classroom assessments and large-scale assessments. Our review generates several important findings. First, although researchers have developed and validated many LP that capture the logical and cognitive aspects of

student development, only one LP includes students' epistemological beliefs. Second, although many LPs and associated curriculum and assessments have been developed, very few studies investigated how teachers understand and use those LPs and associated tools. Third, using the LP approach to enhance the vertical coherence (i.e., alignment between classroom assessment and large-scale assessment) is an important but largely under-researched topic. Based on these findings, we provide suggestions for research and application of LPs.

Makerspace in STEM for Girls: A Physical Space to Develop 21st Century Skills
Rekha B. Koul, Curtin University of Technology
Rachel S. Sheffield, Curtin University of Technology
Susan Blackley, Curtin University of Technology
Nicolleta Maynard, Curtin University of Technology
ABSTRACT:
Makerspace has been lauded as the new way forward to create communities, empower students and bring together enthusiasts of all ages and skill level "to tinker" and create. Makerspace education has been touted as having the potential to empower young people to become agents of change in their communities (European Union, 2015) and the phenomenon has the potential to change the landscape of local libraries and community venues. This paper examines how the emerging Makerspace trend can capture the imagination and creativity of female primary school students, and engage them in STEM-related projects. The project scaffolded female tertiary undergraduate students to mentor small groups of girls to complete a project in a STEM Makerspace. The data generated and analysed from this study were used to determine how Makerspace projects were enacted, how they engaged and supported the girls' learning, and considers the future of Makerspace as a way to move STEM education forward.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
System and Learner Factors
10:30am-12:00pm, HBG Convention Center 007A
Presider: Nancy Romance, Florida Atlantic University

Constitution of Nature in Nature of Science Teaching Practices
Darren G. Hoeg, University of Toronto
ABSTRACT:
This paper is an ethnographic study on the epistemological constitution of nature in Grade 9 and 10 Academic Science in a province in Canada. Critical Discourse Analysis and general inductive analysis were performed on interview transcripts and texts related to teaching science selected by participants. Findings indicate specific, dominant, and relatively uniform epistemological constitutions of nature. Nature was frequently constituted as a remote object, distant from and different than students studying it. Epistemological constitutions of nature were enacted through practices that typically engaged students in manipulating nature; controlling nature, and dominating nature. Few practices that allow different constitutions of nature than those prioritized by the institution were observed. Dominant constitutions generally assume nature is simply the material to study, from which objective scientific knowledge can be obtained, with little ethical or moral consideration about nature itself. This objective knowledge is prioritized in science activities that attain a position of privilege in local science teacher cultures. This system of coordination is sustained through discourse that empowers teaching practices that align with institutional priorities of measuring performance, while at the same time, limiting teachers from being able to conceive of other teaching practices that might enable different constitutions of nature.

Expecting Success? College Students' Beliefs about Majoring in Engineering
Shiyu Liu, Ocean University of China
ABSTRACT:
The present study aimed to explore the nature of engineering students' beliefs about their collegiate experience. Building on the expectancy-value theory (Eccles, 1984; Wigfield & Eccles, 1992) and Tinto's framework of student persistence, we explored how different aspects of student beliefs may contribute to their academic performance in engineering. Seven hundred and twenty-two students participated in this quantitative study. The current findings revealed that students' expectancy beliefs and task value beliefs about pursuing engineering in their studies and future career were closely related to their perceived support from the environment. At the same time, resources and support from the institution they studied at were of particular importance when students made judgments on the value of majoring in engineering. This work added to our understanding of engineering students' beliefs and provided important implications for postsecondary engineering education.

Pre-doctoral Factors Influencing BMS-PhD Entry and Retention: A Qualitative Study
Devasmita Chakraverty, Washington State University
Donna B. Jeffe, Washington University
Robert H. Tai, University of Virginia
ABSTRACT:
Despite the higher retention/graduation rates of PhD students in biomedical-science (BMS) compared to other science fields, the biomedical-research workforce faces unique challenges in terms of increasing its demographic diversity and retaining highly qualified

students in a very competitive research environment. We aimed to uncover some of the pre-doctoral factors that influence BMS-PhD program entry (compared to entry in other programs such as MD or MD-PhD). Our research question is: "What personal and educational experiences before PhD program entry (pre-doctoral factors) were important to students' choice of both field and school and persistence in their current BMS program?" We interviewed 29 currently enrolled students and inductively analyzed qualitative data to uncover the following themes: relevant life experiences prior to PhD entry (included educational and personal factors), PhD program selection criteria (mainly based on research focus, funding, school environment, and family factors), and reasons for choosing PhD over MD or MD-PhD (included serving people through research over clinical practice). This study advances our understanding about the factors that determine BMS program selection, strengthens existing literature about the importance of early research experiences, and indicates the importance of providing students with richer exposure to lab and field experiences early in their BMS training.

STEM Coach as Facilitator of Connectivity in and beyond a School District
Michael Giamellaro, Oregon State University, Cascades
Debbie Siegel, Oregon State University, Cascades
Alyssa Lopez, Oregon State University, Cascades
ABSTRACT:
STEM education has taken on many identities, many of which include interdisciplinarity and connections beyond the classroom. These practices can easily become barriers to implementation for teachers with many demands on their time. In this study we implemented the use of a STEM Coach whose primary responsibility was to create and maintain meaningful connections between teachers, their curricula, and content professionals from outside the school. We used a mixed-methods design to collect teacher, administrator, STEM Coach, and others' perspectives on the role of the coach as a connector with and beyond the educational system. In addition, we conducted a social network analysis to gauge professional collaboration in and out of the schools at multiple points in time. During the first year of implementation, the coach was associated with a significant increase in the connectivity of the district's professional network as the coach became the most heavily connected node within it. Educators' journals and interviews indicated that they highly valued the role of the coach as a connector, particularly to outside resources and people. This approach has promise for other school systems that find connecting across disciplines and outside the institution to be a barrier to STEM implementation.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Practices and Beliefs from Experienced Teachers Inside the Elementary Classroom
10:30am-12:00pm, HBG Convention Center 006A
Presider: Tammy D. Lee, East Carolina University

A 3 Year Longitudinal Multi-case Study Exploring Three Elementary Teachers' Model-based Science Instruction about Water
Tina Vo, University of Nebraska, Lincoln
Cory T. Forbes, University of Nebraska, Lincoln
Laura Zangori, University of Missouri
Christina V. Schwarz, Michigan State University
ABSTRACT:
The water cycle is a complex system spanning K-12 science curriculum standards (NGSS Lead States, 2013). While scientific modeling can help support students' learning around multifaceted phenomena, elementary teachers are crucial in supporting students' engagement in this important scientific practice. However, we still know little about how elementary teachers support students' scientific modeling. This longitudinal multi-case study explored how three teachers' learning about and engagement in model-based instruction developed over multiple years. Findings show that while teachers' early conceptions of modeling were similar, their ideas diverged over time with variation in their emphasis on modeling practices and epistemic dimensions of modeling. These divergences were linked with the perceived needs of their students and favored modeling practices over epistemic considerations. This study's findings highlight that teachers' conceptualizations play a large part in their practice when engaging students in modeling, and the importance of explicitly linking epistemic ideas in science to students' needs within hydrological contexts, such as the water cycle. While scientific modeling practice is also important, it seemed teachers were more readily able to accept and incorporate those ideas with less assistance. Over time each teacher developed more sophisticated ideas of scientific modeling, consistent with authentic science practice.

Dialogic Teaching To Establish Consensus: Social Negotiation, Epistemic Engagement, and Conceptual Development
Ying-Chih Chen, Arizona State University
ABSTRACT:
Dialogic teaching, as opposed to monologue, not only provides opportunities for students to encounter others' arguments but also creates a space to immerse students in negotiating ideas in order to establish consensus. Grounded in a qualitative, interpretative approach, this study explored how a fifth-grade teacher framed dialogic teaching to establish consensus through three harmonious goals while students learned about the human digestive system: social negotiation, epistemic engagement, and conceptual development. Three episodes, consisting of a total of ten events from whole-class discussion, were purposefully selected for analysis. The data analysis led to the creation of a schematic model that explains the dialogic move toward consensus establishment. Central to

the model is the intertwined, dynamic, and progressive nature of dialogic teaching with regard to the contexts in which teachers orchestrate these three goals to extend students' conceptual understanding.

Dimensions of Attitudes towards Science (DAS): A Translation and Validation for the U.S. Context
Jillian L. Wendt, University of the District of Columbia
ABSTRACT:
The Dimensions of Attitudes towards Science Instrument (DAS), a potentially promising instrument to measure elementary teachers' attitudes toward teaching science, was originally written in Dutch and validated with a population of elementary teachers from the Netherlands. It has since been translated and validated in Spanish and Turkish. The purpose of this study was to review the development and evolution of the DAS, translate the DAS into English, and examine its psychometric properties with a U.S. sample population of elementary teachers. After translation and expert review, the DAS was administered to a sample of 300 U.S. in-service and pre-service teachers. The fit indices values supported a seven-factor theoretical model. The DAS was also found to have good internal consistency. This study confirmed the DAS is a valid instrument for a U.S., English-speaking elementary teachers.

Elementary Teacher Characteristics: Predictors of Science Subject Matter Knowledge?
Leigh K. Smith, Brigham Young University
Ryan Nixon, Brigham Young University
Richard R. Sudweeks, Brigham Young University
ABSTRACT:
Research suggests elementary teachers' limited subject matter knowledge (SMK) is at least partially explained by inadequate science preparation. However, other teacher characteristics might also account for variation in elementary teachers' SMK. This study explored how teachers' years of experience teaching a particular grade level, current grade level assignment, science teaching self-efficacy, science coursework, science-related professional development (PD), and time spent teaching science explain the variation in elementary teachers' SMK in the science topics they are assigned to teach. A science content test that included topics from 5th and 6th grade curriculum and all items from the Personal Science Teaching Efficacy Belief scale of the STEBI were administered to 438 5th or 6th grade teachers. Three sets of regression models indicated science teaching self-efficacy was a significant predictor of SMK, while other teacher characteristics (years of teaching experience, number of science courses, number of PDs) did not predict SMK. Total number of PD experiences, number of science courses, and time devoted to science instruction per week predicted teachers' science teaching self-efficacy, which may suggest that these experiences have an indirect and positive effect on teachers' SMK by increasing their self-efficacy. Implications for preservice and inservice teacher education will be discussed.

Epistemic Orientation toward Teaching Science as a Conceptual Framework for Teacher Development
Jee Kyung Suh, University of Iowa
Soonhye Park, North Carolina State University
Brian M. Hand, University of Iowa
ABSTRACT:
This study explored teacher Epistemic Orientation toward Teaching Science (EOTS), which was defined as a teacher's set of interrelated beliefs that they develop and utilize when teaching science. This multiple-case study examines beliefs and practices of three exemplary elementary teachers who were devoted to encouraging student engagement in science practices that are addressed in Next Generation Science Standards (NGSS). The findings of this study suggest that teacher education programs must teach more than strategies and skills: a teacher's epistemic orientation should be prioritized or at least considered in teacher education program to improve the teaching of science in the K-12 classroom.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Related Paper Set: Conceptualizing, Assessing, and Validating Content Knowledge for Teaching Energy in Physics
10:30am-12:00pm, HBG Convention Center 007B
Discussant: Joseph Krajcik, Michigan State University
ABSTRACT:
The construct of Content Knowledge for Teaching (CKT) represents the knowledge teachers need to understand subject matter content in ways that are specific to teaching, such as: understanding challenges that specific content might present to students and how students may represent their understanding in non-standard forms and knowing how to ask questions or provide explanations that move understanding forward. This symposium represents the most extensive study of science CKT undertaken to date and presents a set of papers that conceptualizes, assesses, and validates the construct of CKT within the domain of mechanical energy taught in introductory physics (CKT-E). We report on the theoretical underpinnings of CKT-E that led to the design, development, and administration of a CKT-E assessment to 330 physics teachers. We then provide validity evidence of CKT-E that examines not only what teachers know about the teaching of energy but also how they enact that knowledge in the context of practice. We studied intensively 32 classrooms and examined the relationship of CKT-E to teacher enactment through classroom observations, examinations of classroom assessments, and other instructional artifacts as well as the relationship to student learning of energy concepts.

The Conceptual Framework and Research Design for Studying CKT in Physics (CKT-E)
Ruth A. Anderson, FACET Innovations, LLC
Jim A. Minstrell, FACET Innovations
Drew H. Gitomer, Rutgers University
Courtney A. Bell, Educational Testing Service

Design, Development, and Findings of a CKT-E Assessment
Jim A. Minstrell, FACET Innovations
Geoffrey Phelps, Educational Testing Service
Drew Gitomer, Rutgers University

Validating CKT-E through the Enactment of Instruction — Classroom Observations
Courtney A. Bell, Educational Testing Service
Robert Zisk, Rutgers University
Drew Gitomer, Rutgers University

Validating CKT-E through the Enactment of Instruction — Classroom Artifacts
Robert Zisk, Rutgers University
Drew Gitomer, Rutgers University
Courtney A. Bell, Educational Testing Service

Conceptualizing, Assessing, and Validating Content Knowledge for Teaching Energy in Physics
Joseph S. Krajcik, Michigan State University

Strand 5: College Science Teaching and Learning (Grades 13-20)
Motivation and Learning
10:30am-12:00pm, HBG Convention Center 007C
Presider: Matthew A. Mendicino, University of Georgia

Factors that Influence Community College Students' Interest in Science Coursework
Hope M. Sasway, Suffolk County Community College
Angela M. Kelly, Stony Brook University
ABSTRACT:
There is a need for science education research that explores student, instructor and course characteristics that influence student interest and motivation to study science at the community college level. How to increase student enrollment in and persistence in STEM is a national concern. Nearly half of all college graduates have passed through a community college at some point in their higher education, therefore, studying this unique population of adults is relevant. This study at a large, ethnically diverse, suburban community college showed that student interest tends to change over the course of a semester, and these changes are related to student, instructor, and course variables. Student characteristics that were significant included age, full/part-time status, parental status, and whether the student already held a post-secondary degree. Significant instructor characteristics included whether the instructor taught full or part-time, and whether the instructor taught high school. The type of biology course and if that course had a required library assignment were significant course-level characteristics that affected student interest. These data suggest that interventions may be beneficial for increasing interest and motivation, ultimately leading to more community college students persisting in the pipeline to join in the STEM workforce or transfer to four-year colleges.

Measuring Situational Interest in Earth Sciences
John P. Madura, Education Development Center
Josephine Louie, Education Development Center
ABSTRACT:
A study was conducted to gather validity and reliability evidence for an adapted measure of situational and individual interest. In the study, a self-report instrument was administered to undergraduates in a four-year undergraduate institution enrolled in an Earth history and evolution course (n = 105). Confirmatory factor analyses (CFA) supported a hypothesized three-factor model that organizes situational interest into how well an activity grabs student attention, the extent to which the course material is enjoyable and engaging, and value of the course material. The study provides evidence that the instrument can be easily adapted to measure different instructional situations, and the factor structure is robust across content domains and student populations of different ages.

Motivating Students In Course-Based Undergraduate Research Experiences (CUREs): Comparing College Science Courses Using Self-determination Theory
Stephen C. Scogin, Hope College
Marissa Marks, Hope College
ABSTRACT:
Many institutions have turned to course-based undergraduate research experiences (CUREs) as a way to involve more students in authentic science. However, assessments of CUREs are slow to emerge, particularly in the life sciences. The current case study used mixed methods and self-determination theory to compare introductory and intermediate CUREs on how basic psychological needs satisfaction differed between students in the courses. One-hundred thirty-one (131) students completed the Basic Needs Satisfaction Survey (BNSS), an instrument measuring how specific domains contributed to students' motivational resources. For the qualitative portion, interviews were conducted with 23 students (18 from introductory and 5 from intermediate). Statistical comparisons indicated students in the intermediate course felt significantly more autonomous than introductory students, with no differences in students' feelings of competence or relatedness. Qualitative data indicated students felt less autonomous with larger class sizes and desired freedom to try new things without grade penalty. While reducing class size is difficult, CURE developers can organize research teams within a class to facilitate more autonomy. Furthermore, CURE facilitators can provide students with learning environments that promote scientific risk-taking without grade penalty. Overall, this study contributes to CURE development efforts promoting greater student engagement and more authentic science learning environments.

Student-centered Learning Environments' Impact on Student Motivation and Learning in Introductory Biology
Kimberly Pigford, North Carolina State University
Miriam Ferzli, North Carolina State University
ABSTRACT:
Interest in reform-based teaching practices is increasing at the college level resulting in higher uses of student-centered instructional practices. Student-centered learning has been shown to increase student performance in undergraduate STEM courses, yet little research has been done examining how and why student-centered learning environments are more successful than traditional formats in undergraduate STEM courses. This phenomenological study examined student perceptions of a large introductory biology course taught using a collaborative, student-centered learning environment. Focus groups were conducted to discover the impact of the

learning environment on student motivations for learning. Data were analyzed using the self-determination theory of motivation, which focuses on providing three specific psychological needs to support learning: competency, autonomy, and relatedness. Learning formats which support these needs encourage the development of higher autonomous motivation leading to higher performance and self-regulated learning behaviors. Findings of this study show that the collaborative, student-centered learning format provides teaching and learning approaches that meet all three needs with an emphasis on relatedness as being most important from the student perspective. This study supports student-centered teaching practices in a large STEM introductory undergraduate course and provides an explanation for academic and affective gains for students learning in such environments.

Strand 6: Science Learning in Informal Contexts
Symposium: Natural History Museums as Communicators for the Nature of Science: Research Approaches on Visitors' and Scientists' Perceptions
10:30am-12:00pm, HBG Convention Center 006B
Presider: Kerstin Kremer, Kiel University Germany
Discussant: Alexandra Moormann, Museum für Naturkunde
Presenters:
Kerstin Kremer, Kiel University Germany
Alexandra Moormann, Museum für Naturkunde, Berlin
Charlène Bélanger, Université du Québec à Montréal
Anik Meunier, Université du Québec à Montréal
Patrick Charland, Université du Québec à Montréal
Maritza Macdonald, American Museum of Natural History
Lourdes López, University of Granada Spain
María-Dolores Olvera-Lobo, University of Granada Spain
Marjorie Rhodes, New York University
Daniel Zeiger, American Museum of Natural History
ABSTRACT:
Many science discoveries completely changed our way of looking at the world and will require society to have scientific knowledge to deal with them, the ability to make decisions and to assess their importance as well as their future applications. In natural history museums the gap between the laboratory research sphere and the public sphere of science becomes evident as for more than 100 years most natural history museums around the world have separated its research collection from its display collection. The challenge for educating people for responsible citizenship in modern civilization will be to bridge the gap between the "invisible" research in the museum laboratories and ways of communicating this research in the museum public collection. Education research should elucidate how visitors can gain meaningful and authentic perceptions of the nature of science in these settings. Therefore, all research approaches in this symposium contribute investigations on visitor understanding of different aspects of the nature of science from natural history museums in Europe and the US. Different research methodologies and theoretical framings are taken into account and are discussed for evidence on meaningful ways of communicating the nature of science.

Strand 6: Science Learning in Informal Contexts
Topics in Science Communication: Controversial Issues and Use of Social Media
10:30am-12:00pm, Hyatt Travis AB
Presider: Stephanie B. Wortel-London, Stony Brook University

Aren't You Afraid of Getting Sick?: Using Social Networking to Explore Food Waste and Sustainability
Kathleen A. Fadigan, Pennsylvania State University
ABSTRACT:
Food loss is a growing concern both nationally and globally. Increases in world population, decreases in available landfill space, and economic loss are factors contributing to interest in this issue. Informal science education can support the public understanding of this issue. This exploratory, qualitative, Participatory Action Research (PAR) study investigates the use of social networking sites in engaging adult learners in the socioscientific issue of food waste and sustainability through dumpster diving. On a daily basis for one month, the researcher visited supermarket dumpsters and documented through her personal Facebook page the details of each “dive”, including written and visual accounts of the rescued items, items left for the landfill, and meals prepared using dumpster food. The participants are comprised of 104 Facebook “Friends” who engaged with the researcher’s daily dumpster postings. The researcher analyzed the posts to determine participants’ level of engagement, their knowledge of, attitudes toward, and changes in behavior regarding food waste and sustainability. Results reveal that participants expressed a high level of interest as well as some misconceptions about food safety. Several participants visited dumpsters and reported their findings to the researcher. Implications include using social networking sites as venues for public understanding of science.

Ask Dr. Twitter: Characterizing Social Media Claims about Controversial Science Issues

Anita S. Tseng, Stanford University

ABSTRACT:
This study examines the nature of commentary on the social media platform Twitter regarding controversial science issues, and analyzes these comments for the presence of potential misinterpretations of science. The advancement of the Internet has made more science information available to the public. However, new Web technology allows Internet users to self-publish claims and share them with a worldwide audience, increasing the spread of misinformation and inaccurate explanations. For this study, Twitter posts ("Tweets") on two recent, controversial socio-scientific issues were collected daily over three months. Results from qualitative analysis of a random subset are forthcoming, but preliminary results from pilot data find potential misrepresentations of scientific information when comments are viewed from a lens of scientific epistemology. Misrepresentations range from the use of anecdotal evidence for claims against established scientific findings, overgeneralization of conclusions drawn from models used in research, and citation of uncertain scientific language in anti-science claims. Findings from this research may have implications for scientific literacy in formal and informal education, including an increased emphasis on scientific epistemology and valid interpretation of science information, as well as adding to the extant research on new impacts of user-generated information on public understanding of science.

Conceptualizing Social Paleontology: An Exploration of Mental Models
Lisa M. Lundgren, University of Florida
Kent J. Crippen, University of Florida
Eleanor E. Gardner, Florida Museum of Natural History
Victor J. Perez, Florida Museum of Natural History
Ronny Maik Leder, Leipzig Natural History Museum

ABSTRACT:
The FOSSIL Project, an NSF-funded initiative, seeks to unite amateur and professional paleontologists in the practice of social paleontology —an inclusive form of computer-supported collaborative inquiry of the natural world through the collection, preparation, curation, and study of fossils (Authors, 2016). Social paleontology is enacted across a digital habitat of technologies (Wenger, White, & Smith, 2009) that includes Facebook, Twitter, as well as an online social space of our design. Wenger's (1998, 2000) construct of community of practice serves as the theoretical framework for our design. The purpose of this study was to explore the relationship between potential community members' social media personas and their mental model of social paleontology. We examine the responses of citizens, amateurs, and professional paleontologists who completed a survey, a mental model task concerning the meaning of social paleontology and a follow-up interview. In addition to building our capacity to successfully design a community-centered social space, the results inform our understanding of contemporary science learning, that which is inherently social, technology-mediated, occurs outside of formal schooling, involves people from across the life-span, and recognizes the value of situated practice.

Museum Staff Expectations for Critical Science Exhibitions: Lessons from Brazil
Ana Maria Navas Iannini, University of Toronto
Erminia G. Pedretti, University of Toronto

ABSTRACT:
Critical exhibitions represent a new direction in the science museum landscape. Through complex and controversial topics, located at the intersection between science and society, these displays tend to challenge dominant narratives and promote active engagement of visitors (Pedretti & Dubek, 2015). In this work, we focus on museum staff's expectations behind the mounting of two Brazilian science exhibits: one about teen pregnancy, the other about drug consumption. Both exhibitions are considered to be highly controversial and critical in nature. Data was collected through interviews with the staff (curators and educators), field observations of the exhibits and documents. Analyses revealed the emergence of five major themes that speak about: practical scientific literacy; connections with schools; pathways to NOS; a space to challenge beliefs; and youth autonomy and inclusion. Those findings align with progressive views of scientific literacy and they open up possibilities for exploring the role of critical exhibitions.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers and Efficacy
10:30am-12:00pm, HBG Convention Center 007D
Presider: Todd Milford, University of Victoria

Examining Relationship of Preservice Teachers' Self-efficacy Beliefs and Drawings of their Science Teaching, and their Classroom Practice
Sanghee Choi, University of North Georgia

ABSTRACT:
The Purpose of the study was to examine preservice teachers' self-efficacy beliefs in science teaching and how they perceived their beliefs through their drawings. The preservice teachers' teaching practices in their placement classroom were also analyzed to understand the relationship between self-efficacy beliefs and perceptions of themselves as a science teacher. This study proposed three research questions: (1) what level of self-efficacy beliefs do preservice teachers have; (2) what perceptions do these teachers have of

themselves as a science teacher; and (3) how do these teachers teach science in their classroom. The participants in this study were 52 preservice elementary teachers. STEBI-B, DASTT-C (Draw-A-Science Teacher-Test Checklist), and Intern Keys Assessment were used. The results indicate that the participants' beliefs in their abilities and skills to teach science effectively were uncertain to low. Their DASTT-C and Intern Keys Assessment scores suggested that the preservice teachers in this study were more teacher-centered and they actually performed teacher-centered science instruction in their placement classrooms. The teacher efficacy belief, thus, provides a useful framework for predicting teacher-teaching behavior by examining a person's belief in his or her own competency in addition to the preservice teachers' images of their teaching.

Self-efficacy of Secondary Science and Mathematics Student Teachers
Janelle M. Bailey, Temple University
Noelle A. Luccioni, Temple University
ABSTRACT:
High self-efficacy has been shown to correspond with success whereas low self-efficacy can be a hindrance. This study presents the findings in how self-efficacy changes in 24 secondary preservice teachers of science or mathematics over the course of their student teaching semester. An analysis of matched pretests and posttests, as well as weekly administrations throughout the semester of question subsets, were performed on a modified version of the Science Teaching Efficacy Belief Instrument (STEBI-B) and Mathematics Teaching Efficacy Belief Instrument (MTEBI). In addition to responding to these instruments, student teachers provided weekly reflections of happenings that may have contributed to their weekly survey responses. These data were analyzed to note sources of self-efficacy, as well as expressions of emotions, triumphs, or discouragements by student teachers throughout the semester. The results indicated statistically significant improvements in self-efficacy for teaching science or mathematics over the course of the student teaching semester. Identification of changes in self-efficacy throughout the student teaching semester can provide insight to precisely what impacts the PST's experience, holding implications for changes in student teaching programs.

The Effect of Collective Efficacy on Group Performance regarding Preparing Science Lesson Plans
Volkan Atasoy, Kastamonu University
Jale Cakiroglu, Middle East Technical University
ABSTRACT:
Collective efficacy has been seen as an important motivational construct influencing group performance. Although there were several studies regarding group work about science teaching or learning, the effect of collective efficacy on the group performance has not been investigated thoroughly. In addition, there is a lack of studies examining collective efficacy among preservice teachers in the literature. Therefore, the purpose of the present study was to analyze the influence of collective efficacy on preservice science teachers' group performance on preparing science lesson plans. This study was conducted in the science methods course. Case study was implemented. A group who included four preservice science teachers was selected as a case of the study. Lesson plans and interviews are used as data collection tools. The results of this study pointed out that the group members considered themselves successful in preparing the science lesson plans, and this success was improved continuously. As the reason of their success, while some group members mentioned that they developed the belief about the group in the process, the others stressed that the sources of collective efficacy, which are mastery experience, vicarious experience, verbal experience, and psychological and affective states, were responsible for the improvement.

Strand 7: Pre-service Science Teacher Education
Related Paper Set: Learning to Teach Elementary Science: Using Practice-based Teacher Education to Support Teacher Learning and Practice
10:30am-12:00pm, Hyatt Crockett CD
ABSTRACT:
These four related papers add to and extend understandings of how a practice-based approach might support elementary preservice teachers' learning. Papers 1 and 2 highlight potential areas of strength and challenge within preservice teachers' lesson plans and enactments around supporting students in learning science content integrated with science practices. The findings suggest potential leverage points and needed foci within science teacher education. Papers 3 and 4 discuss the role of tools, rehearsals, and teacher educators in developing elementary teachers' practice, having implications for the development of practice-based approach and science methods courses. All four papers describe approaches to support elementary preservice teachers' learning to facilitate all students' sense-making of science concepts in science integrated with science practices through the development of ambitious science teaching practice.

Content Knowledge for Teaching Science: How Preservice Elementary Teachers Use their Knowledge of Science Content and Practices
Amber S. Bismack, University of Michigan
Elizabeth A. Davis, University of Michigan
Annemarie S. Palincsar, University of Michigan

Supporting Beginning Teacher Planning of Investigation-based Science Discussions
Sylvie M. Kademian, University of Michigan
Elizabeth A. Davis, University of Michigan

Scaffolding Beginning Teaching Practices: An Analysis of the Roles Played by Tools Provided to Preservice Elementary Teachers
Sarah J. Fick, Wake Forest University
Anna Maria Arias, Illinois State University

Attending to Student Thinking in Rehearsals: Exploring the Connections Between Teacher Educator Feedback and Novice Teacher Noticing
Amanda Benedict-Chambers, Missouri State University

Strand 8: In-service Science Teacher Education
Socioscientific Issues
10:30am-12:00pm, HBG Convention Center 008A
Presider: Stephen B. Witzig, University of Massachusetts Dartmouth

Decision-making Patterns of Science Teachers: A Case of Genetics Dilemmas
Umran Betul Cebesoy, Usak University
Ceren Oztekin, Middle East Technical University
ABSTRACT:
Issues discussed in genetics literacy literature require a deep understanding of genetics knowledge as well as making informed-decisions regarding these issues. When making decisions, individuals are faced with moral and ethical considerations that are introduced with these issues. The purpose of this study was to examine Turkish in-service science teachers' reasoning patterns and the factors underlying their decision-making processes. 18 science teachers participated individually in four semi-structured interviews that were designed to elicit their ideas, opinions and feeling about some genetics dilemmas covered in genetics literacy. Qualitative analyses revealed that the most emergent factor that influenced their decisions was moral considerations. Participants' moral considerations were based on either their utilitarian analyses of the consequences of processes or the application of principles in issues in genetics literacy. Moreover, affective features as emotive and value considerations were also influential in their decision-making process. In addition to moral considerations, their decisions were influenced by other factors such as socio-cultural, religious, technological, political and legal considerations as well as personal experiences and family biases. Description of each factor used in this study along with corresponding percentages and sample excerpts were presented. Findings offer viewpoint to audience how teachers' practices influenced from multiple sources.

Enhancing K-12 Teachers' Cultural Awareness Through Reflections of Socioscientific Issues in a STEM Education Course
Augusto Z. Macalalag, Arcadia University
Joseph A. Johnson, Mercyhurst University
ABSTRACT:
Much responsibility for preparing and motivating students to pursue careers in STEM and STEM Education depends on PreK-12 teachers. However, the majority of teachers in elementary schools lack the credentials, knowledge and pedagogy to teach STEM subjects. Although there have been strides toward the globalization of STEM Education, more research is needed to expand the knowledge and experiences of teachers regarding socio-scientific issues and diverse cultural perspectives, broadening their viewpoints and allowing them to better meet the learning needs of an increasingly diverse student population. This study applied the SSI framework to explore and understand how elementary teachers navigate STEM curriculum and apply SSI into their classroom practice following a STEM certification endorsement course. Course participation lead to significant shifts in cultural awareness. Analysis revealed a number of themes regarding shifts in teachers' perceived cultural practices in their classrooms. Specifically, themes emerged regarding intersections among the STEM subjects, society, and education, perceived cultural practices of conservation, attention to the development and usage of alternative sources of energy, and food from local and urban gardens indicating a substantial shift in focus for these elementary teachers in teaching science.

Nature of Science and Teachers' Attitudes toward Democratic Teaching and Decision Making
Heba El-deghaidy, American University in Cairo
ABSTRACT:
This study investigated the impact of an in-service development programme in Egypt for in-service science teachers. The programme consisted of the main features of democratic practices that science teachers can employ in their elementary classrooms. It was envisioned that since Egypt is moving towards a new era, where democracy plays a vital role in the life of every citizen, educational systems can adopt such strategy in the everyday teaching and learning practices. Moreover, the field of science is a rich field that employs features of democracy and decision-making through the nature of science (NOS). The study utilised a quasi-experimental design, where instruments to measure dependent variables of the study were developed by the author. Pre and post-instruments were

administered measuring science teachers' attitude towards democratic practices and decision-making. Statistical data analysis indicated that post-test results on both instruments had higher responses compared to results of the pre-tests. The specific design of the programme may be responsible for these results.

The Influence of SSI Pedagogical Development Course on Science Teachers' PCK and Argumentation
Emil Eidin, Weizmann institute of scince
Yael Shwartz, The Weizmann Institute of Science
ABSTRACT:
Embedding SSI in science class is part of the means for achieving scientific literacy among students. However, science teachers face difficulties and challenges when they come to practice SSI in the class. We designed a pedagogical development course for teachers that could answer some of those challenges. A large portion of the PD focuses on different ways to asses arguments in a SSI context. We taught fundamentals of formal logic, informal fallacies and Toulmin's argument analysis. Our goal was to study the influence of our PD design on teachers' knowledge and PCK. We used questionnaires, interviews and repertory grid technique as methods to answer our questions. Results demonstrate that teachers acquired pedagogical tools which allow them to assess arguments followed by an increased ability to practice SSI. The teachers were sorted into three major groups based on their approach to SSI. We observed different attitudes between teachers who participated in the PD and those who didn't, the first group focused on the teacher's knowledge and the latter focused exclusively on the teacher's practice. In addition interviews revealed the importance of informal logic to the teachers SSI practice.

Strand 10: Curriculum, Evaluation, and Assessment
Related Paper Set: STEM Coursework, Post-secondary Training and Employment Outcomes: Backwards Mapping of the Ideal Curricula
10:30am-12:00pm, HBG Convention Center 006C
Presider: Stacey Britton, University of Mississippi
ABSTRACT:
This themed paper set employs big data research to inform the reverse design of curricula that will better serve students and optimize STEM interest, success, and retention. Collectively, these research studies utilized large data sets and longitudinal data to develop an understanding of how a student's exposure to STEM classes in high school can influence college performance and/or degree path, including 1) characteristics of a high school experience that increase the likelihood of success for postsecondary STEM degrees; 2) high school STEM classes' influence in pursuing a college mathematics or science major; 3) difference in outcomes for students that enter directly into a 4-year institution versus those that transfer from a junior college; and 4) students' earning comparisons after entering into the STEM workforce. Findings reveal the extent to which STEM curricula have been narrowed as a result of standardized testing, and the unintended consequences that have permeated into postsecondary training outcomes. The researchers will discuss how findings from big data research can inform local policy, drive innovation in STEM education and workforce development, and promote a STEM-based economy.

Exploring Secondary Education STEM Curricula using State Longitudinal Data System
Ryan M. Walker, Mississippi State University
Renee M. Clary, Mississippi State University
Gabriel A. Posadas, Mississippi State University
Katie Huston, Mississippi State University
Christina Hillesheim, Hiwassee College
Stacey Britton, University of Mississippi
Aressa Coley, Mississippi State University

The Relationship Between High School STEM Exposure and STEM College Outcomes
Renee M. Clary, Mississippi State University
Ryan M. Walker, Mississippi State University
Gabriel A. Posadas, Mississippi State University
Katie Huston, Mississippi State
Stacey Britton, University of Mississippi

STEM Post-Secondary Training Pathways
Gabriel A. Posadas, Mississippi State University
Ryan M. Walker, Mississippi State University
Renee M. Clary, Mississippi State University
Katie Huston, Mississippi State University
Stacey Britton, University of Mississippi

Post-Secondary STEM Graduates Entering into the Workforce

Katie Huston, Mississippi State University
Ryan M. Walker, Mississippi State University
Renee M. Clary, Mississippi State University
Gabriel A. Posadas, Mississippi State University
Stacey Britton, University of Mississippi
Shana Lee, Mississippi State University

Strand 12: Educational Technology
Symposium: Lessons from a Decade of Video Game Research for Students with Disabilities in Science Education
10:30am-12:00pm, Hyatt Travis CD
Presider: Len Annetta, East Carolina University

Lessons from a Decade of Video Game Research for Students with Disabilities in Science Education
Sheri Berkeley, George Mason University
James D. Basham, University of Kansas
Matthew T. Marino, University of Central Florida
Eleazar Vasquez, University of Central Florida
Aubrey Whitehead, George Mason University
Amanda Luh, George Mason University
Benjamin Gallegos, University of Central Florida
Maya Israel, University of Illinois, Urbana Champaign
Len Annetta, East Carolina University
ABSTRACT:
Information presented in this symposium is the result of a decade of related research supported in part by the National Science Foundation, the U.S. Department of Education Institute of Education Sciences, and the Office of Special Education and Rehabilitative Services. Research teams will share experiences and findings from current and previously funded federal projects to support students with disabilities and other students who have difficulty with science content. Throughout the symposium, presenters will share specific studies and then interlink findings from these studies to current and previous work in the field with attention toward research, development, and implementation of serious educational games (SEGs) in science education environments. This strand will support the advancement of research through the discussion of issues within primary game research, design, and implementation, including the major issue of measurement. With support from a symposium moderator, information from these presentations will interconnect findings from a decade of video game research to support insights in teaching, learning, and researching science education with a focus on advancing equity across learning environments through the use standards and theoretically-based SEGs. The symposium will include a question/answer segment facilitated by a moderator with expertise in gaming research.

Strand 13: History, Philosophy, and Sociology of Science
Differing Perspectives on Nature of Science and Science Education
10:30am-12:00pm, Hyatt Seguin AB
Presider: Ryan Summers, University of North Dakota

A Three Part Framework for Locating Aspects of NOS in the Enterprise of Science
Daniel Z. Meyer, Illinois College
Allison Antink-Meyer, Illinois State University
ABSTRACT:
Nature of science (NOS) has long had the challenge of being a somewhat amorphous entity. Despite the clear consensus to have student understanding of NOS be a major goal of science education, and a clear consensus on specific aspects of science to teach. NOS easily remains a daunting challenge, in part, because of its complex, ambiguous character. Indeed, ambiguity is arguably part of the point. A black and white view of science is precisely the naive view we are trying to avoid. In this theoretical paper, we present a framework that seeks to assist in the instruction on NOS by considering where in the enterprise of science they occur. It is not intended as an alternative to existing articulations of NOS, but rather as a lens through which to consider them. It can serve as both a heuristic for class discussion and as a guide to instructional planning.

Autonomy, Power and Science Education
Wayne Melville, Lakehead University
Donald Kerr, Lakehead University
Todd Campbell, University of Connecticut
Geeta Verma, University of Colorado, Denver
ABSTRACT:

In this conceptual presentation we examine how the concept of autonomy may be construed as a foundational value which underpins students' coherent sense-making of how the physical world operates. Participation in scientific sense-making affords opportunities for dialogue, agency and power, while autonomy stresses a concern for the quality of the decisions that students arrive at regarding themselves, their participation in the scientific enterprise, and the reasoning behind their decisions. In particular, we focus on how autonomy provides a foundation for the education of students as "epistemic agents". Our conceptualization of autonomy and its importance in science learning indicates that the development of students' autonomy is predicated on carefully examining and challenging the traditional power relationships found within classrooms. By pursuing the goal of autonomy, and challenging the often entrenched power relationships found in science classrooms, we argue that the values disconnect between science, society and science education can be addressed.

Nature of Science Treatment in U.S. Science Standards: A Historical Account with Contemporary Implications
Ryan Summers, University of North Dakota
Sahar K. Alameh, University of Illinois, Urbana Champaign
Jeanne Brunner, University of Massachusetts, Amherst
John Maddux, Collegiate School of Medicine and Bioscience
Robert C. Wallon, University of Illinois, Urbana Champaign
Fouad Abd-El-Khalick, University of North Carolina, Chapel Hill
ABSTRACT:
The present study reports on an analysis of 153 state science standards documents, collected from all 50 states representing the 1980s through the present, for their treatment of key aspects of nature of science (NOS). We used to a structured rubric to examine 10 different NOS aspects on each document. Results indicate that the inclusion and representation of some NOS aspects have improved dramatically over the past several decades (e.g., empirical NOS), while others continue to near absent (e.g., theory-laden NOS) or poorly addressed (e.g., inferential NOS). The identification of historical patterns in the treatment of NOS in state science standards allowed inferences to be made about the extent to which these patterns were consistent with advances in scholarship on the philosophy of science. The treatment of NOS in recent standards raises timely questions regarding changes in curricular outcomes in light of the NGSS. Our analysis adds to the discussion of these contemporary issues, and concerns, of NOS representation by highlighting luminary states for their explicit and informed treatment of NOS aspects.

Theories, Laws and Models as Scientific Knowledge Forms and Their Inclusion in Science Teacher Education
Ebru Kaya, Bogazici University
Sibel Erduran, University of Oxford, UK
ABSTRACT:
Curriculum standards from around the world place an emphasis on teaching and learning of scientific knowledge. There is evidence that students and teachers can have difficulty distinguishing forms of scientific knowledge such as theories and laws.. This paper aims to describe the types of scientific knowledge such as theories, laws and models and their contribution to the growth of scientific knowledge. We designed an intervention consisting of a set of workshops as part of a funded project for a pre-service teacher education programme in Europe. Data sources stem from a group of 4 pre-service teachers who are chemistry majors. We focus on the data sources from the posters generated during the workshop, lesson plans developed by the focus group, and pre- and post-interviews with individual pre-service teachers. Using qualitative data analysis, the results show that pre-service teachers improved their perceptions of scientific knowledge after the intervention. The paper contributes to the articulation of different forms of scientific knowledge as well as knowledge growth, and illustrates how these ideas can be integrated in science teacher education.

Strand 15: Policy
Admin Symposium: Conceptualizing Organizational Processes in Science Education Reform: A Set of Theoretical Tools
10:30am-12:00pm, Hyatt Crockett AB

Conceptualizing Organizational Processes in Science Education Reform: A Set of Theoretical Tools
Kathryn N. Hayes, California State University
Sara Heredia, The University of North Carolina, Greensboro
Carrie D. Allen, SRI International
John Settlage, University Connecticut
William R. Penuel, University of Colorado
ABSTRACT:
As science education reform efforts associated with NGSS gather steam in districts across the nation, many of us in the NARST community find ourselves immersed in the work of school change – and encountering unfamiliar organizational challenges related to implementation of science education reform (NASEM, 2016). Rather than relying on common sense notions, there is a need for surfacing and discussing the theoretical tools available to parse such organizational processes and inform our actions. In this session, we pose four productive conceptual tools for understanding teacher learning and district implementation efforts: sensemaking (Spillane, et al., 2002), structure-agency (Holland & Lave, 2009), CHAT (Cole, 1996), and infrastructure (Star, 1999). The presenters will each apply a different body of theory to analyze one piece of data: an observation and recording drawn from a multidistrict

science education reform effort. Each presentation will share the insights made possible by using a particular theory in analyzing participant negotiation of district structures and processes for supporting the implementation of NGSS. Our purpose is not to suggest any single theory as the theory, but rather to model the possibilities of being deliberative and thoughtful when researching and supporting district organizational reform initiatives.

Concurrent Session #8
2:30pm – 4:00pm

Presidential Sponsored Session
Admin Symposium: Cross-Countries Collaborations for a Glocalized Science Education
2:30pm-4:00pm, HBG Convention Center 008B
Presiders:
Mei-Hung Chiu, National Taiwan Normal University
Sibel Erduran, University of Oxford, UK
Discussant: Avi Hofstein, Weizmann Institute of Science, Israel
Presenters:
Joe Krajcik, Michigan State University
Jari Lavonen, University of Helsinki
Mei-Hung Chiu, National Taiwan Normal University
Rachel Mamlok-Naaman, Weizmann Institute of Science, Israel
Mustafa Sözbilir, AtatÜrk Üniversity, Turkey
Sibel Erduran, University of Oxford, UK
George DeBoer, AAAS
ABSTRACT:
Three cross-countries partnerships in glocalized science education will present in this symposium, sharing their experiences and recommendations for adapting internationalized science education in their respective countries. The first partnership is a collaborative work between the US (Joe Krajcik) and Finland (Jari Lavonen) focusing on ways of adapting project-based learning (PBL) to make sense of phenomena and design solution to problems making use of big ideas, scientific and engineering practices and crosscutting concerts from the Framework for K - 12 Science Education and the Next Generation of Science Standards. Chemistry and physics teachers from both countries work collaborative with science educators to design PBL materials that will engage high schools students in meaningful tasks. Developing a professional learning community across both countries where ideas are exchanged in what works and does not work is a key to implementation of the program. The second partnership is a comparative collaboration among 10 researchers from Australia, Chile, Germany, Israel, Japan, Malaysia, Massachusetts, the Netherlands, Taiwan, and Turkey sponsored by International Union of Pure and Applied Chemistry (IUPAC). The goal of the project was to develop operational definitions, adopt them for analyzing curriculum standards, and present examples for macro, sub-micro, symbols and interpretations of the scientific phenomenon (Mei-Hung Chiu, Rachel Mamlok-Naaman, & Mustafa Sozbilir). The third partnership involves collaborations between researchers in the United Kingdom, Turkey and South Africa. The research involves curriculum analysis and teachers' professional development on argumentation in secondary science education (Sibel Erduran). Finally, George DeBoer will discuss the growing trend toward international science education standards. He will argue that if there is science knowledge and skills that all students should have to be effective citizens of the world, then countries should be encouraged to work together to identify what that knowledge is and what those intellectual skills are.

Strand 1: Science Learning, Understanding and Conceptual Change
Fostering and Assessing Students' Understanding of Climate Change
2:30pm-4:00pm, HBG Convention Center 006D
Presider: Michael Giamellaro, Oregon State University

Middle Schoolers Developed Systems Thinking while Designing Computer Games about Climate Change
Gillian Puttick, TERC
Michael Cassidy, TERC
Eli Tucker-Raymond, TERC
ABSTRACT:
Through a theoretical framework emphasizing participatory pedagogies as compelling learning spaces for schools, this paper explores how two classrooms of 8th grade science students engaged in systems thinking through game design about climate change. The data for this study are taken from Year 1 of a larger design research project on teaching climate systems and computational thinking through the design of computer games. Through a focus on student work and discussion related to climate systems and game design, this paper explores the tensions of how students demonstrated systems thinking as they constructed their computer games.

Additionally, this paper considers implications for curriculum developers and teacher instruction to support systems thinking through game design.

Students' Model-Based Explanations about Carbon Cycling and Climate Change through Socio-Scientific Issues Based Learning
Laura Zangori, University of Missouri
Amanda N. Peel, University of Missouri
Andrew T. Kinslow, University of Missouri
Patricia J. Friedrichsen, University of Missouri, Columbia
Troy Sadler, University of Missouri
ABSTRACT:
Carbon cycling is a key natural system that requires robust science literacy to understand how and why climate change is occurring. However, students tend to compartmentalize carbon movement within plants and animals and are challenged to make sense of the connection between global carbon cycling and climate change. To support secondary students in understanding this complex system, we situated carbon cycle learning within a socio-scientific issue based curriculum exploring the effects of climate change. Students engaged in the practices of modeling to develop models about carbon cycling and used their models as sense-making tools for climate change. Over the course of the intervention, students' causal mechanisms about carbon cycling shifted in complexity to understand the carbon system was out of balance with more carbon outputs than inputs causing climate change. We also found their knowledge building occurred along a continuum of partial understandings in which some elements of carbon cycling and/or climate change were still unknown to them. Identifying and understanding gaps that appear in students' reasoning is critical so that these gaps may be bridged within classroom instruction. Results suggest that this is an important area for future research to support students in building science literacy.

Assessing Student Learning about Global Climate Change through Science and Engineering Practices
Erin Burkett, Michigan Technological University
Brenda G. Bergman, Michigan Tech University
ABSTRACT:
The Next Generation Science Standards (NGSS) call for new curriculum and assessment materials that focus on students' ability to use Science and Engineering Practices to apply previous knowledge of Core Ideas to new problems and contexts. The Michigan Science Teaching and Assessment Reform "Mi-STAR" project created and pilot-tested a 30-day Global Climate unit that covered global climate change from both local and global perspectives in two Michigan middle schools in 2015-2016. During the pilot we assessed how students' ability to recall Core Ideas differed from their ability to apply that content in a new context using a Practice, and how this differed before and after experiencing the Global Climate unit. We found that students consistently scored higher on Content-only based multiple choice and short answer questions than on questions that asked them to apply their Content knowledge in new, Practice-based contexts such as graph interpretation or constructing an explanation. These initial findings expand on existing transfer learning theory, highlight the need for NGSS-based curricula materials that introduce students to the Practices throughout all grade levels, and offers insights into how curriculum developers and educators can assess student learning from an NGSS-based perspective.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Assessing Factors Supporting Learning
2:30pm-4:00pm, HBG Convention Center 007A
Presider: Pei-Ling Hsu, University of Texas

Combination of Worked-out-examples and Feedback for Promoting the Understanding of the Energy Concept
Matylda Dudzinska, Leibniz Universität Hannover IDMP AG Physikdidaktik
Gunnar Friege, Institute for Mathematics and Physics Education
ABSTRACT:
In our research project we focused on learning with worked-out-examples with prompts and different kind of feedback and chose the energy concept as central physics topic. We developed and tested a computer-assisted learning environment based on six worked-out examples with prompts and with experiments covering the topic energy conservation. This learning environment allows us to gather the needed data in an easy accessible manner (e.g. reactions on prompts), control variables (influence of the teacher, teaching method) and has economic reasons also. The impact of worked-out examples and feedback were investigated in a pre- and post-test design with six different intervention groups according to the factor prompts (expert-like / novice-like) and the factor feedback (teacher / self / no feedback). In addition, we collected data from log files (text field, diagrams etc. generated by the students). The learning success was measured by an energy test that has been evaluated by a Rasch analysis. 16 regular physics classes (N = 385 students from the 9th grade) participated. We will present the results concerning the impact of different kind of prompts as well as of different kind of feedback. The interaction of prompts and feedback will be addressed, too.

Development and Validation of an Instrument for Assessing Students' Attitudes Towards Graphing
Laura K. Ochs, University of Virginia

Frackson Mumba, University of Virginia
ABSTRACT:
The aim of this study was to develop and validate an instrument for assessing students' attitudes towards graphing (SATG). In particular, we focused assessing students' attitude towards graphs commonly used in science curriculum (bar graphs, pie charts, and line graphs). The initial 40-item survey was administered to 410 high school students. Students responded to items using a 5-point Likert-Scale (Strongly Agree to Strongly Disagree). Exploratory factor analysis was performed on the data and resulted in a reduced 30-item survey addressing three constructs of students' attitude towards graphing; Value, Cognitive Competency, and Interest. The final solution accounts for 46.65% of the observed score variance and 40.70% of the shared variance among the variables, and all of the variables have sufficient factor loadings of greater than 0.3. Results show that the instrument is valid and reliable for assessing students' attitudes toward graphing.

The Effect of Post-lesson Assessment and Evaluation on Permanent Learning and Cognitive Load
Nesli Kala Aydin
ABSTRACT:
The aim of this study is to examine the effect of the post-lesson assessment and evaluation on permanent learning and cognitive load. Pretest-posttest applied experimental research design was used for this aim. The data have been collected using Thermodynamics Academic Achievement Test, Cognitive Load Scale and Digit Span Memory Test. Besides, a software of eight sessions for the subject of thermodynamics and its four laws has been used in the research. The sample of this study consists of 47 pre-service teachers studying Science Teaching in an education faculty of a state university in Turkey. Consequently, the students in the Cognitive Load Theory Plus Evaluation group have lesser loads, even though partially, and to score higher in the permanence test in comparison with Cognitive Load Theory group. However, these differences are not to be statistically meaningful.

The Relationship Between Dialogic Teacher Feedback and Student Outcomes on Standardized Science Assessment
Mason Kuhn, University of Northern Iowa
Mark A. McDermott, University of Iowa
ABSTRACT:
The use of inquiry practices in science classrooms as a method for engaging students is widely considered by science educators as critical pedagogy. However, teachers often struggle to employ specific effective behaviors to encourage the argumentation called for in Argument Based Inquiry (ABI) approaches. The study discussed here included two main explorations. First, s tool to assess the degree to which teachers utilized and encouraged interactive dialogical discourse patterns in their classrooms, the Dialogic Feedback Observation Tool (DFOT) was developed. Secondly, the tool was used to analyze classroom practices of 33 Grade 3 – 8 teachers to help evaluate whether the tool could be used to predict student performance on a standardized measure of science understanding. Results of the study indicate that the tool is a significant predictor of performance on the standardized measure of science understanding, and therefore may be a valuable research and instructional tool. The procedure utilized to carry out this study, as well as findings and potential implications will be discussed.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Related Paper Set: Improving Early Childhood Science: A Comprehensive Approach
2:30pm-4:00pm, Hyatt Seguin AB
Presider: Charlene M. Czerniak, University of Toledo
ABSTRACT:
Science exposure in early childhood (PreK-3) has many benefits. Participation in science inquiry creates opportunities to build language arts and mathematics skills, while also enhancing and accelerating the development of critical thinking skills and providing opportunities for high-level discourse. Despite extensive research showing the benefits of science in early childhood education, most early childhood classrooms provide few opportunities for students to engage with science in any form, and even fewer experience science taught through inquiry-based practices. This may be due to lack of exposure to instructional practices for science during Early Childhood teacher preparation programs and little to no available professional development in science teaching. An NSF funded program, NURTURES, aims to improve science education for young children. NURTURES includes two primary components: (a) teacher PD and (b) family engagement in scientific inquiry. This paper set provides results from research that has been conducted on these components, such as: the impact of coaching methods to improve teacher practice, the long-term impact of PD on teacher participants, the use of science activity packs to extend school science into the home, and an analysis of standardized test scores to show the impact of inquiry-based teaching on student achievement.

Elementary Science Teachers' Experiences with Synchronous Online, Asynchronous Online and Face-to-Face Coaching
Amanda M. Gilbert, University of Toledo

The Effects of Coaching Using a Reflective Framework on Early Childhood Science Teachers' Depth of Reflection and Change in Practice
Debra L. Bloomquist, University of Toledo

Long Term Changes in K-1 Teacher Practice While Enacting NGSS-Aligned Science Inquiry
Nicole A. Tuttle, University of Toledo

A Detailed Analysis of Family Utilization of Science Activity Packs
Lacey Strickler, University of Toledo

The Impact of Science Professional Development on Student Achievement
Charlene M. Czerniak, University of Toledo
Nicole A. Tuttle, University of Toledo

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Science Teachers' Knowledge
2:30pm-4:00pm, HBG Convention Center 007B
Presider: Italo Testa, University Federico II Napoli

A Solomon Islands Study of School-Based Science Assessment and Teacher Pedagogical Content Knowledge
Lionel C. Kakai, Curtin University
Tony W. Rickards, Curtin University
ABSTRACT:
Science teachers' pedagogical content knowledge (PCK) is essential in conducting effective School-Based Assessment (SBA) for multiple purposes. Students must be able to trust that their teachers are experts when scaffolding for conceptual understanding. This paper presents data from a case study that sought to explore and document the views and experiences of trainee and practising science teachers in the Solomon Island. This study utilised a survey and face-to-face interviews to collect data about teaching knowledge, learner's knowledge, teacher purpose and PCK for use in the SBA of physics concepts. Preliminary findings from the study indicate that participants have general knowledge and understanding about teaching, learning and assessment of physics concepts. Participants support the use of SBA for multiple purposes although time, large class size, and lack of resources were identified as constraints. Findings also indicated a greater divergence in conceptual understanding of Newtonian force concepts than expected. Participants indicated a need to strengthen their confidence in teaching and assessment of physics concepts at senior high school level.

Exploring Subject Matter Knowledge among Science Teachers: The Potential of Concept Sketches
Julie A. Luft, University of Georgia
Ryan Nixon, Brigham Young University
ABSTRACT:
The subject matter knowledge (SMK) that a science teacher holds is considered essential to his or her teaching. As a result, researchers are exploring the SMK of teachers and those in teacher education are crafting programs to improve the SMK of teachers. Unfortunately, is it not clear in the educational community as to what constitutes SMK (NRC, 2013). With continued interest in this area in science education, there is a great need to characterize the SMK that a science teacher needs or holds. This paper suggests one approach to the characterization of SMK. It also reviews the research related to SMK and early career science teachers. Drawing upon this information, the SMK among 13 preservice and newly hired science teachers was explored using concept sketches. Examining the concept sketches in terms of the core content knowledge, specialized content knowledge, and the linked content knowledge, revealed that teachers need to enhance their SMK. This article ultimately contributes to the needed conversation pertaining to SMK, and suggests that more research is needed in this area and that an educative orientation towards SMK is timely.

Master Teachers' Topic-Specific Pedagogical Content Knowledge (TSPCK) of Electrochemistry
Stephanie M. O'Brien, Stony Brook University
Angela M. Kelly, Stony Brook University
ABSTRACT:
This study evaluated the means by which eight chemistry master teachers demonstrated their PCK to transform chemistry content within the topics of oxidation, reduction and electrochemistry, thus this examination establishes a framework for topic specific pedagogical content knowledge (TSPCK) in redox and electrochemistry. The first phase of the study called for teachers to complete a validated TSPCK instrument in redox and electrochemistry. The exam responses were coded to align with particular components of TSPCK they assessed. The second phase consisted of interviews with each of the research participants to gain an understanding of how their TSPCK in redox and electrochemistry guided their decision-making. The chemistry master teachers displayed varying levels of TSPCK in redox and electrochemistry, as evidenced by their knowledge of student misconceptions, curricular saliency, and knowledge of what makes the topic difficult to teach. There was evidence of master teachers lacking in certain areas of TSPCK, such as inability to identify student misconceptions, suggesting the need for programmatic improvements in pre-service and in-service training to address the needs of current and future chemistry teachers. To facilitate TSPCK development, new strategies need to be developed to connect research to practice.

Pedagogical Content Knowledge and Cognitive Activation as Influencing Factors for Students' Learning in Biology
Christian Förtsch, LMU Munich
Sonja Werner, LMU Munich
Lena Von Kotzebue, LMU Munich
Birgit Jana Neuhaus, LMU Munich
ABSTRACT:
The presented study focuses on effects of biology teachers' domain-specific dimensions of professional knowledge—content knowledge (CK) and pedagogical content knowledge (PCK)—and the instructional quality feature cognitive activation on students' achievement. Therefore, CK and PCK of 39 biology teachers from German secondary schools was assessed using open-ended paper-pencil tests. Two lessons of each teacher on the topic neurobiology were videotaped and analyzed with regard to cognitive activation using a rating manual. Their students (N = 827) completed an achievement test pre and post videotaping. Multilevel path analyses were used to test an upper level mediation. Results showed that cognitive activation positively effected students' achievement. Additionally, teachers' PCK showed a positive indirect effect on students' achievement, mediated through cognitive activation. In contrast, teachers' CK did not show a significant effect on cognitive activation, nor on students' achievement. The findings of this study emphasize the importance of PCK as an independent knowledge dimension. Additionally, implications for preservice biology teachers' university education can be drawn. The cognitive activation rating manual can provide concrete exemplars of cognitively activating instruction, which can be included in preservice teachers' university studies and in professional development initiatives of in-service teachers.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Pre-Service Teacher Learning in the Content Disciplines
2:30pm-4:00pm, HBG Convention Center 007C
Presider: Binaben H. Vanmali, Arizona State University

An Examination of Preservice Elementary Teachers' Learning about Chemistry Epistemic Practices
Minjung Ryu, Purdue University
Meng-Yang Wu, Purdue University
Jocelyn Elizabeth Nardo, Purdue University
ABSTRACT:
The chemistry education aspect of elementary teacher education faces a unique set of challenges. On one hand, preservice and in-service elementary teachers tend to not like chemistry and to have negative feelings toward chemistry. On the other hand, learning chemistry requires reasoning about natural phenomena from the submicroscopic perspective that deals with properties and behaviors of unobservable entities, such as atoms and molecules. The present study addresses these challenges in chemistry education for future elementary teachers by designing a chemistry curriculum drawing on research-based recommendations for chemistry education and assessing students' learning about chemistry. An analysis of chemistry representations that elementary education majors generated before and after taking the designed chemistry course demonstrates that they initially perceived chemistry as vivid macroscopic changes occurring in lab spaces and chemists as lab technicians. After taking the course, many students came to see doing chemistry as epistemic practices that construct submicroscopic explanations of observable phenomena and its relevance to everyday lives and environmental issues such as climate change. This study provides important implications for engaging preservice elementary teachers in chemical reasoning and designing chemistry curricula that is more approachable for them.

Pre-Service Teachers' Reasoning Resources on Argumentative Conceptual Physics Problems
Carina M. Rebello, Purdue University
ABSTRACT:
Scientific argumentation has been highlighted in the Next Generation Science Standards (NGSS) as one of the key science and engineering practices. While there have been relatively few studies on student argumentation in physics, research has shown that the use of argumentation prompts can potentially improve not just the argumentation quality, but also the conceptual quality of undergraduate student responses to written conceptual physics problems. In this study we extend previous research to look more closely at the impact of construct and evaluate argumentation prompts on the reasoning resources pre-service elementary teachers enrolled in a conceptual physics class bring to bear on conceptual physics problems. We examine the kinds of conceptual resources used by the when justifying their claim and also when they constructed a rebuttal to a counter argument. Further we analyze the scientific accuracy and pedagogical appropriateness of these resources.

Biological Evolution Acceptance Among Pre-service Primary Teachers
Mustafa B. Aktan, Hacettepe University
ABSTRACT:
In recent years, a growing body of knowledge has emerged in evolution education. Today, most researchers and educators support the idea that Darwinian evolution is key to becoming a science literate citizen as well as a successful teacher. Hence, in light of this view, this study investigates and presents the results of research on pre-service primary teachers' acceptance of evolution. A total of 125

Turkish, senior level pre-service teachers voluntarily participated in the study. The data collection was two steps: First, the demographic data, such as gender, age, family income level, etc. were collected. Second step was the collecting data by using the Measure of Acceptance of the Theory of Evolution (MATE) instrument. The MATE score of 60.17 (SD = 12.11) was found, indicating the low level of acceptance among the participants. The results showed that 65.9 % of the participants reject the theory of evolution while only 9.2 % accept biological evolution. Also, 90 % of the conservative participants reject evolution, while 53.9 % of the liberals reject the theory. There was a strong evidence to suggest that most Turkish pre-service primary teachers were opposing to evolutionary concepts and they did not find the theory of evolution credible.

Investigating Cognitive Processes in Inquiry Lab Tasks at the Undergraduate Level
Ines Sonnenschein, Humboldt-Universität zu Berlin
Jenna Koenen, Humboldt-Universität zu Berlin
Rüdiger Tiemann, Humboldt - Universität Zu Berlin
ABSTRACT:
The purpose of this study is to investigate how theoretical knowledge about the inquiry practices influences the performance on inquiry lab tasks. Therefore, we designed an inquiry task to apply in the undergraduate analytical chemistry laboratory. Seven undergraduate bachelor students and five undergraduate pre-service teachers participated in this study. At this point of tertiary education, the number of learning opportunities is equal for both groups concerning content knowledge as well as lab experiences. Since university curricula of pre-service chemistry teachers include theoretical knowledge about scientific inquiry, which is not the case for the undergraduate chemistry students, it is valuable to investigate whether the performance on the inquiry task differs depending on the theoretical knowledge of scientific inquiry. To explore this field, a multiple case study was chosen by using video analysis and think aloud protocols. Data analysis was made by using a theory-driven coding manual. The results suggest a need for explicit training about scientific inquiry at the undergraduate level since the trained students follow more consequently the practices of scientific inquiry. Conducting inquiry experiments seems to be more challenging for untrained students, this is especially valid for the processes of defining a research question and identifying the relevant variables.

Strand 6: Science Learning in Informal Contexts
Related Paper Set: Pathways to STEM Identity: Investigations with Underserved Youth in Informal Settings
2:30pm-4:00pm, HBG Convention Center 006B
Presider: John H. Falk, Oregon State University
ABSTRACT:
Despite decades of research, policy work, and educational initiatives, there remain deep and persistent disparities in STEM engagement and career participation for women and youth from traditionally underserved communities. In addition to ongoing work addressing institutional and structural barriers, understanding and supporting STEM identity development for youth and young adults has emerged as a central line of research in this area, and one with particular relevance for informal learning. Although many scholars have embraced identity as a powerful theoretical lens and an important focus for investigation, the concept remains challenging to operationalize, with different researchers adopting often conflicting perspectives and conceptualizations. To advance these ongoing conversation, presenters in this session will provide an overview of research on STEM identity over the last several decades and will highlight three recent studies with youth from traditionally underserved communities participating in informal, out-of-school education programs. The three studies highlight the complex ways that youth negotiated and authored their identities, the affordances and constraints inherent to the programs, and the methods used by researchers to effectively investigate these processes. The session will conclude with a group discussion to engage attendees in synthesizing key ideas from the presentations and identifying next steps for future research.

Developing a Descriptive Framework of Situated Identity Negotiation for Adolescents Participating in an Informal Engineering Education Program
Scott A. Pattison, Oregon Museum of Science and Industry
Ivel Gontan, Oregon Museum of Science and Industry
Smirla Ramos-Montanez, Oregon Museum of Science and Industry

"We've Learned that Anyone can be a Scientist": How Museum Program Design Supports *Youth's Stem Linked Identities*
Carrie D. Allen, SRI International
Vera Michalchik, Stanford University
William R. Penuel, University of Colorado

Traces: Emerging Short-Term Outcomes of Informal/Free-choice STEM Experiences among Girls of Color and Their Potential Long-term Influence on Identity Building
Lynn D. Dierking, Oregon State University
Heidi B. Carlone, University of North Carolina at Greensboro

Strand 7: Pre-service Science Teacher Education

Preservice Teachers and Science Practices
2:30pm-4:00pm, HBG Convention Center 007D
Presider: Julianne A. Wenner, Boise State University

Pre-service Science Teachers' Modelling-strategies
Moritz Krell, Freie Universität Berlin
Susann Hergert, Freie Universitaet Berlin
Dirk Krueger, Freie Universitaet Berlin
ABSTRACT:
To teach science in line with the demands imposed by the shift towards scientific practices, science teachers need to develop meta-modelling knowledge and modelling skills. However, there is a lack of research about the way pre-service science teachers engage in scientific modelling, which may be used to develop evidence-based teacher education programs. This study provides such research by qualitatively analyzing pre-service science teachers' modelling-strategies while being engaged in a black-box activity. In addition, the subjects' meta-modelling knowledge is assessed using constructed response items. Data analysis is done within the framework of qualitative content analysis using a theoretically consistent and empirically validated category system. So far, four pre-service science teachers participated in this study. The subjects perform different modelling-strategies. For example, expressive modelling, where to focus is on developing a model which has the power to retrospectively explain observations but not on testing the model by deducing and testing predictions. No coherent relationship between meta-modelling knowledge and performed modelling-strategies could be found. At NARST conference, the methodical approach will be proposed as a way to analyze science teachers' modelling-strategies and findings will be presented based on an enlarged sample.

Preservice Teachers' Use of Curriculum Materials to Engage Students in Data Analysis
Anna Maria Arias, Illinois State University
Luminita Hartel, Illinois State University
ABSTRACT:
Science learning involves engaging in science practices integrated with science content, yet facilitating this engagement is difficult, especially for beginning teachers. More information is needed on how to support teachers' learning in this area and how curriculum materials (e.g., textbooks, online plans) can support this work. This study examines how preservice teachers enrolled in one middle school science methods course select and modify lesson plans from curriculum materials to plan and enact science lessons that engage students in analyzing and interpreting data. Findings suggests that the existing lesson plans selected by the preservice teachers had both positive and negative features for facilitating students to analyze data. The preservice teachers often added additional supports for analyzing data (e.g., discussing interpretations of data representations) to existing lesson plans, yet other teachers removed learning opportunities from the existing selected materials. These findings have implications for teacher educators and curriculum developers.

Prospective Teachers' Knowledge for Constructing Concept Maps: An Analysis of the Quality of Concept Maps
Pamela Harrell, University of North Texas
Karthigeyan Subramaniam, University of North Texas
EunYoung Lee, University of North Texas
ABSTRACT:
The purpose of this study was to investigate the nature of prospective elementary science teachers' knowledge underpinning the technique used to construct concept maps and thus, explicate their facility to construct concept maps. Literature contends that a teacher's knowledge of concept map-based tasks influences how their students create acceptable concept maps and thus, teachers need to (1) understand and apply the appropriate operational terms to construct concept maps; (2) identify the legitimacy of the constructed concept map by verifying it's graphical structure and it's educational utility; and (3) determine the inherent "good" and "poor" qualities of the resulting graphical structure to reiterate the "good" qualities and to coach and provide feedback to alleviate "poor" qualities. Analysis of 200 concept maps constructed by prospective teachers revealed that these future teachers had predominantly constructed either hierarchical and/or non-hierarchical concept maps. Most of these concepts maps only contained the root concept and subordinate concept, and lacked directional linking lines, linking phrases, and labeled lines. Implications include the need for teacher educators to derive their prospective teachers' understanding of high leverage practices like concept mapping in relation to the nature and quality of the graphical structures and how they impact and/or effectuate learning.

What Should I Have My Students Do? The Nature of Tasks Selected by Pre-sevice Teachers
Kirby Whittington, Florida State University
Miray Tekkumru Kisa, Florida State University
Sherry A. Southerland, Florida State University
Christine Andrews-Larson, Florida State University
ABSTRACT:
Current reform efforts emphasize shifts from superficially teaching science ideas to supporting students' making sense of phenomena and designing solutions to problems by engaging in disciplinary practices. This goal requires teachers to provide opportunities for students to engage in the practices of science in the service of sense making about the natural world. Yet, teachers struggle to provide tasks that provide more rigorous opportunities for students' learning in science. In this study, we look at the types of tasks pre-service

teacher select during their full-time teaching internship to add to the literature on the types of tasks selected by teachers. Conducting a quantitative analysis of 118 tasks and semi-structured interviews, findings indicate that PTs generally planned to implement low cognitively demanding tasks. Additionally, participants struggled to identify task features related to the level and kind of cognitive effort required in the task. Participants generally misidentified practices embedded within tasks, superficially discussed how students would be engaged, and discussed content difficulty as reasons why they planned to implement the task. Therefore, we see this work of interest to those looking at high leverage practices within science education as well as researcher focused on the design and improvement of teacher education programs.

Strand 8: In-service Science Teacher Education
Professional Development Needs & Delivery
2:30pm-4:00pm, HBG Convention Center 008A
Presider: Augusto Z. Macalalag, Arcadia University

Development of a Scale for Assessing Science Teachers' Professional Development Needs for Teaching Collaborative Problem Solving
Shu-Ching Wang, Shuang Shih Junior High School
Kuo-Hua Wang, National Changhua University of Education
ABSTRACT:
Teachers' needs for professional development are often neglected by professional development program. One possible reason is lack of valid instruments to understand teachers' needs. In this study, we report on a process of developing an instrument to assess science teachers' perceptions of professional development needs for CPS teaching. The instrument for the study is the scale of "Teachers' Perceptions of Professional Development Needs for Collaborative Problem Solving Teaching (TPoPDN-CPS)." The initial version of TPoPDN-CPS included 20 Likert-scale items and was administered to 164 secondary school science teachers in Taiwan, including 40.2% biology science teachers, 57.4% physical science teachers, and 2.4% earth science teachers, for the purpose of conducting item and factor analyses. Results indicate that after deleting 3 items from initial version and then performed exploratory factor analysis, the TPoPDN-CPS demonstrate validated factor structure, acceptable reliability, and good convergent validity. The new TPoPDN-CPS scale can be grouped into new three subscale, consisting "needs for understanding modeling and resources for teaching CPS", "needs for understanding of Teaching strategies and beliefs on CPS", and "needs for Professional Learning and practices of CPS teaching."

Examining the Instantiation of Teacher Leader Knowledge During the Enactment of Professional Development
Laura A. Shafer, University of California Davis
Cynthia Passmore, University of California, Davis
ABSTRACT:
Professional development is seen as an important resource for expanding teachers' knowledge and beliefs around the implementation of education reforms. The analysis of teacher knowledge is usually not situated as a designer or facilitator of professional development (PD). This study is unique in that we examine the knowledge of teacher leaders who are positioned as both PD designers and facilitators. We analyze how teacher leader knowledge is instantiated during the enactment of PD. Our findings show teacher leaders' knowledge was instantiated into strategic protocols and resources that facilitated aligning their goals for NGSS practices-based instruction with classroom activities. We suggest a number of ways in which these findings can help educators and PD developers to better structure activities that not only present an alternative vision for science education, but also provide the needed resources to shape the way classroom activities are managed in service of transforming reforms like NGSS into classroom practice.

Power of Data Facilitation Academy: Designing Facilitator Professional Development
Brooke A. Whitworth, Northern Arizona University
Nena Bloom, Northern Arizona University
Megan Walker, Northern Arizona University
Lori Rubino-Hare, Northern Arizona University
ABSTRACT:
This design-based research study examined the first cycle of development, enactment, analysis, and redesign of the Power of Data (POD) Facilitation Academy (FA). Facilitators' geospatial technology (GST) skills, understanding of POD Principles, and preparation for and stages of concern for implementing POD Teacher Workshops were investigated. The POD Team, consisting of geologists, GST experts, and science educators, analyzed previous POD professional development (PD) models. Using these results the first POD FA and Guide were developed and enacted. One cohort (n=15) participated in the POD FA designed to prepare facilitators to implement POD Teacher Workshops and support teachers in learning how to incorporate GST through Geospatial Inquiry. Data sources included surveys, daily debriefs, observations, performance assessments, and interviews. The qualitative data were analyzed using deductive analysis. Quantitative data were analyzed using descriptive and non-parametric statistics. Analysis of data informed the redesign and modification of the POD FA. Findings may provide a better understanding of the stages of concern facilitators hold prior to implementing PD which may provide insight into the support facilitators need in the implementation and scaling up of PD. We begin to suggest design principles for scaling up teacher PD.

The Impact of Technology-Enhanced Professional Development in Science on Students' Learning
Hyunju Lee, Utah State University
Max L. Longhurst, Utah State University
Todd Campbell, University of Connecticut
ABSTRACT:
This research reports investigated teacher learning in a two-year technology-enhanced professional development (TPD) for teachers and its impact on their students' achievement in science. Thirty-six science teachers participated in TPD focused on information communication technologies (ICTs) and their applications into science inquiry pedagogy. Three self-reporting teacher instruments were used alongside their students' achievement scores on the end-of-year state-science-test. The teacher self-reporting measures were a measurement of technological skills, ICT capabilities, and pedagogical beliefs about science inquiry. Data was collected at baseline, after one-year of PD, and after two-year of PD. We used descriptive statistics, t-test, and Pearson's correlations to analyze the data. We found teachers' technological skills and ICT capabilities increasing over time with significant gains each year. Additionally, teachers' pedagogical beliefs about science inquiry pedagogy also increased over time, however the gains were not significant until after the second year of PD. The correlation results showed that the students' performance was correlated to the teachers' pedagogical beliefs, but not to their technological skills nor to ICT capabilities. Our study suggests that pedagogical considerations should be foregrounded in TPD and that this may require more longitudinal TPD to ensure technology integration in science instruction, consequential in terms of student learning.

Strand 8: In-service Science Teacher Education
Symposium: Innovations in Equity-Centered Teacher Learning
2:30pm-4:00pm, Hyatt Presidio ABC
Presenters:
Julie C. Brown, University of Minnesota
Pauline W. U. Chinn, University of Hawaii, Manoa
Meredith W. Kier, College of William and Mary
Veronica McGowan, University of Washington
Felicia Moore Mensah, Columbia University
Philip L. Bell, University of Washington
Alexis Patterson, University of California, Davis
Katie Van Horne, University of Colorado, Boulder
Maria S. Rivera Maulucci, Barnard College
Thomas McKenna, Connecticut Science Center
ABSTRACT:
Teachers face many challenges in organizing equitable classroom spaces for the racially, linguistically, and other historically marginalized students they serve. While most pre-service teacher learning experiences have some space dedicated to discussing issues of equity, however small and ineffective such spaces may be, many in-service teachers find themselves isolated in practice and poorly resourced to make effective classroom based change. This session seeks to bring together researchers and/or practitioners who are engaged in supporting teacher learning in practice specifically focused on one or more intersectional equity-centered problems of practice. This symposium features diverse, yet theoretically connected studies across several sites, including early childhood learning, place-based pedagogy, sociotechnical literacy, and standards implementation.

Strand 9: Reflective Practice
Reflective Practice - Paper Session A
2:30pm-4:00pm, HBG Convention Center 006A
Presider: Banu Avsar Erumit, Indiana University

Developing an Identity as a Scientist: A Comparative Study Illustrating How a Dramatic Inquiry can Support Children to Successfully Engage in being Scientific
Deb J. McGregor, Oxford Brookes University
ABSTRACT:
This is a small scale, but international comparison, of the way two classes (in the UK and NZ) responded to a similar dramatic inquiry experience. The children in both classes were engaged in the same activities for an afternoon. The children were taught by the same (unfamiliar guest teachers). The inquiry plan, materials used and pedagogic approach were consistent throughout the lessons in both countries. The focus of attention was the development of the children's identity and perceptions of science as they progressed through the dramatic inquiry. There were commonalities and differences in the findings. The children overwhelmingly felt they were working like real scientists. The majority of self-narratives also indicated moments of thinking, acting and feeling like scientists. The contrasts suggested that there were curricular influences on the way they described their learning experiences and offered thoughts about their future trajectories.

Learning from Three Young Women's Stories: Recommendations for Teaching Science to Individuals with Disabilities
Lauren Madden, The College of New Jersey
Melissa Friedman, The College of New Jersey
Danielle Koehler, The College of New Jersey
Shanaya Panday, The College of New Jersey
ABSTRACT:
The Next Generation Science Standards (NGSS), citing evidence from earlier reports, assert that, "when provided with equitable learning opportunities, students from diverse backgrounds are capable of engaging in scientific practices and constructing meaning in both science classrooms and informal settings." (p. 1, Appendix D, NRC, 2013) In our study, we explore the science learning experiences of three individuals from one group of students that have traditionally been underserved in science classrooms—individuals with learning disabilities. Three young women with diagnosed disabilities collaborated with a science educator to narrate their personal science learning experiences to identify trends in their learning, compare these trends to the recommendations in the literature, and make recommendations for current and practicing teachers.

The Influence of Parents on Undergraduate and Graduate Students' Entering the STEM Disciplines and Careers
Cheryl J. Craig, Texas A&M University
Paige K. Evans, University of Houston
Donna Stokes, University of Houston
Rakesh Verma, University of Houston
ABSTRACT:
This narrative inquiry examines on the influence of parents on students' studying Science-Technology-Engineering-Mathematics (STEM) disciplines and later pursuing STEM careers. Two students (one male; one female) were Physics majors who were part of a STEM teacher education program; one student (male) was an undergraduate enrolled in a Computer Science program. This National Science Foundation supported research employs the narrative inquiry tools of broadening, burrowing and storying and storying along with serial interpretation, to unearth how three parents intentionally/circumstantially cultivated their children's STEM interests. The academic trajectories on which the students engaged are elucidated. Incidents of both circumstantial and planned parent curriculum making are made visible. Additional themes include: (1) relationships between (student) learners and (teacher) parents; (2) invitations to inquiry; (3) modes of inquiry, (4) the improbability of certainty, and, finally, (5) changed narratives = changed lives.

Using Reflective Soft-Systems Methodology to Describe Next Generation Assessment Research Practices
Christopher D. Murakami, University of Missouri, Columbia
Dante Cisterna, University of Missouri
Marcelle Siegel, University of Missouri, Columbia
Shannon Burcks, University of Missouri
Nilay Muslu, University of Missouri, Columbia
Suleyman Cite, University of Missouri, Columbia
ABSTRACT:
This study focused on the co-authors and members of the Science Education Assessment Research Community of Practice (SEARCoP). The study was initiated when it became evident that the High-Stakes Content Entrance Assessment (HSCEA), a reportedly "Next-Generation Science Standards (NGSS)-aligned" test, was a poor example of an assessment for three-dimensional learning described by the NGSS. This study applied reflective soft-systems methodology to identify the key practices of the SEARCoP when the scholars decided how/if to take action regarding the HSCEA, a test that impacted their students and students throughout the state. Drawing upon the learning experiences of members in the SEARCoP who were at varying stages of their careers, we searched for key practices enacted while negotiating this complex landscape of high-stakes tests. The key practices of the SEARCoP members were: 1) Evaluating the quality of the assessment, 2) Understanding the policy context, and 3) Determining the purposes of high-stakes assessment. Next generation science education researchers need more opportunities to reflect upon and take action for valid and equitable high-stakes assessment systems. Insights about the challenges of action taking regarding high-stakes assessments and strategies that help new scholars meaningfully engage in these issues are discussed.

Strand 10: Curriculum, Evaluation, and Assessment
Related Paper Set: The Processes of Curriculum Development for Three Middle School Projects at Different Stages of Development
2:30pm-4:00pm, HBG Convention Center 006C
ABSTRACT:
With the release of A Framework for K-12 Science Education and the Next Generation Science Standards, a new ideal for science education has been put forth. The NGSS focuses on learning at the nexus of three dimensions, science and engineering practices (SEPs), crosscutting concepts (CCCs), and disciplinary core ideas (DCIs). In order to realize the vision of the Framework and standards, there is a clear call for new instructional materials to be developed. To achieve true three-dimensional learning in a coherent and rigorous manner may prove to be a difficult task for teachers, who have limited time to commit to developing new curriculum for

the classes they teach. To help with this problem, the authoring organizations are each developing middle school units that are reflective of the type of learning that meets the vision of NGSS. The purpose of this paper set is to share the processes that each group is using to develop their curricula, each at a different stage of development. We will also share details about the tools that each group is using to focus on addressing the specific goals for the curricula and to align with NGSS.

Development of the Five Tools and Processes for Translateing the NGSS into Instruction and Classroom Assessment
Dora E. Kastel, American Museum of Natural History
Jody Bintz, BSCS

Three-Dimensional Teaching and Learning: Rebuilding and Researching an Online Middle School Curriculum to Support the NGSS
Brooke Bourdelat-Parks, BSCS
Betty Stennett, BSCS
Zoe E. Buck Bracey, BSCS
Audrey Mohan, Biological Sciences Curriculum Study
Jody Bintz, BSCS
Susan M. Kowalski, BSCS

Designing an NGSS-aligned Middle School Ecosystems Unit using the Five Tools and Processes
Maia K. Willcox, University of California, Berkeley
Barbara Nagle, University of California, Berkeley
Wendy M. Jackson, University of California, Berekeley
Dora E. Kastel, American Museum of Natural History

Redesigning Curriculum for Three-dimensional Teaching and Learning
Wendy M. Jackson, University of California, Berkeley
John Howarth, University of California at Berkeley
Maia K. Willcox, University of California, Berkeley

Strand 10: Curriculum, Evaluation, and Assessment
Contexts and Characteristics in Curriculum and Assessment
2:30pm-4:00pm, Hyatt Republic ABC
Presider: Matthew J. Benus, Indiana University Northwest

An Examination of How Teachers' Beliefs about Scientific Argumentation are Impacted by Multimedia Educative Curriculum Materials (MECMs)
Katherine L. McNeill, Boston College
Maria Gonzalez-Howard, Boston College
Lisa Marco-Bujosa, Boston College
Suzanna Loper, University of California
Laura O'Dwyer, Boston College
ABSTRACT:
Recent reform efforts include a shift to focusing on science practices. Teachers require support in integrating these science practices into their classroom instruction. Multimedia educative curriculum materials (MECMs), which are digital materials explicitly designed to support teachers, offer one potential resource for this critical need. Consequently, we investigated how teachers used MECMs and whether that use impacted teachers' beliefs about scientific argumentation. We conducted a randomized experimental study with 90 middle school science teachers. Both control and experimental groups taught the same curriculum, using a web-based teacher's guide. Additionally, the experimental teachers received the MECMs including 24 videos and 17 interactive reflective prompts. We collected multiple data sources: pre surveys, backend curriculum use, self-report curriculum use, and post surveys. The results suggest that enacting a curriculum with a focus on argumentation can support positive changes in teachers' beliefs about argumentation. Furthermore, we observed a wide range in how teachers used the curriculum. In terms of self-efficacy, this differential use impacted teacher's beliefs. Teachers became more confident in their ability to teach argumentation as they enacted more lessons. Additionally, the MECM teachers had lower changes in self-efficacy, perhaps because the video may have problematized what teachers thought counted as argumentation.

Secondary Science Teachers' Values, Practices, and Proficiency for Classroom Assessment
Gavin W. Fulmer, University of Iowa
Christopher C. Deneen, NIE Singapore
Gavin T. L. Brown, University of Auckland
Wei Shin Leong, NIE Singapore
Kelvin H. K. Tan, NIE Singapore

Hui Yong Tay, NIE Singapore

ABSTRACT:

We examine secondary science teachers' views, practices, and sense of proficiency for various classroom assessment strategies and actions as part of a larger survey study in Singapore. Four factors were identified: aligning assessment; motivating students with assessment; involving students in assessment; and reporting of assessment. Results revealed large, statistically significant differences among teachers on their reported values, practices, and proficiencies for all four factors. Teachers reported valuing aligning assessment, involving students in assessment, and motivating students with assessment much more than they practiced the strategies or felt proficient with them. Teachers practiced reporting of assessment more than they valued, but the difference was not statistically significant. The findings have implications for curriculum and assessment reform efforts as part of attempts to embrace alternative assessment in Singapore, as well as for teacher professional development to address the gaps among values, proficiency, and practice.

Examining the Relationship between Context Characteristics and Student Performance on Context-based Items

Min Li, University of Washington
Maria Araceli Ruiz-Primo, University of Colorado, Denver
Dongsheng Dong, University of Washington
Jim A. Minstrell, FACET Innovations
Xiaoming Zhai, Physics department, BNU

ABSTRACT:

Despite the widespread use of contexts in science testing, their utility, practice, and underlying assumptions have been called into question. As contexts used may interfere with the target construct and lead to inaccurate inferences about student learning, it is important to carefully craft and evaluate the contextualized items even at the stage of item development to ensure that the contexts are appropriately constructed. In this paper, we proposes a conceptual framework for evaluating the quality of contextualized items and provide empirical evidence by constructing three types of items: (1) context-based items without an illustration, (2) context-based items with an illustration, and (3) abstract items. We administered two booklets of 394 students at grades 7-8. By comparing students' performance across the three versions of items, our preliminary analysis found that abstract items were more difficult than context-based items whereas students' performance did not differ between the two versions of with versus without an illustration. Findings of additional analysis that further explore the reasons for students' performance patterns will be reported and practical implications for item construction and validation will be discussed in the paper.

Teacher Learning from an Educative Reform-oriented Science Curriculum: An Exploration of Teacher Curriculum Use

Lisa Marco-Bujosa, Boston College
Katherine L. McNeill, Boston College
Maria Gonzalez-Howard, Boston College
Suzanna Loper, University of California

ABSTRACT:

Educative curriculum materials provide teachers with authentic opportunities to learn new skills and practices. Yet, research shows teachers use curriculum in different ways for different reasons, and these modifications could undermine the learning goals of the curriculum. Little research, however, has examined the variation in teacher use of educative curriculum and the impact on teacher learning. In this article, we use organizational theory's concept of sensemaking to examine teacher learning from educative curriculum. Utilizing a multiple-case study methodology, we explored the variation in how teachers utilized the same educative science curriculum to plan for instruction and learning about argumentation from the curriculum. Findings indicate that some teachers used the curriculum as a resource solely to support student learning, and consequently did not utilize the educative aspects or recognize the intended support for teacher learning. Second, we found that the teachers who actively engaged in their own learning while adapting the curriculum to their context made learning gains, indicating a need for teacher active reflection to learn new practices. Our findings suggest a need to shift teachers' perspectives from viewing curriculum as a source of activities to a resource to support their own learning and professional goals.

The Role of Optional Discussion Activities in Supporting Motivation in a STEM Massive Open Online Course

William L. Wildberger, University of Florida
Pavlo D. Antonenko, University of Florida
Chris Mortenson, University of Florida

ABSTRACT:

This study was designed to explore the role of optional online discussions and learners' self-reported motivation and self-efficacy in a Massive Open Online Course (MOOC) in Animal Science. Study participants were 210 MOOC students who completed a previously validated survey of motivation. Learners who engage in optional online discussions and perceive them as useful reported higher levels of motivation to learn. Discussion participation was also a significant predictor of intrinsic and extrinsic goal orientation. Both Asian students and those in the 13-17 age range reported the highest levels of extrinsic motivation. Finally, participation in online discussions positively influenced students' self-efficacy, which is significant, particularly in the context of STEM learning where students generally report lower self-efficacy.

Strand 12: Educational Technology
Teachers' Perceptions of Technology
2:30pm-4:00pm, HBG Convention Center 006A
Presider: Bridget T. Miller, University of South Carolina

Exploring Fossils with 3D Technologies: A Study of Teachers' Perspectives of Integrated STEM
Pavlo D. Antonenko, University of Florida
Claudia Grant, University of Florida
Sean Moran, University of Florida
Bradford Davey, Technology for Learning Consortium, Inc.
Bruce MacFadden, University of Florida
Adam Wade, Santa Cruz County Office of Education
ABSTRACT:
This study explored the evolution of middle and high school teachers' perspectives regarding the integration of STEM disciplines in K-12 education as they collaboratively designed activities aligned with the three dimensions of science learning and using 3D scanners and printers in the context of paleontology. Data sources included focus group interviews at the beginning of the project, interviews before, during, and after the professional development activities, and researcher notes based on observations. Findings revealed initial understandings such as "there cannot be too much STEM integration," "technology and engineering are more challenging to integrate than science and mathematics," and "technology, engineering, and math are means for improving science learning." Evolving perspectives included "3D scanning and printing contribute the "T" and the "E" to help integrate STEM," "STEM disciplines can be integrated around the authentic practice of modeling," and "STEM integration is not always useful" among others. Our findings support the recommendations provided by the National Research Council Committee on Integrated STEM Education and demonstrate that it is important to provide opportunities for teachers and STEM experts to engage in focused conversations about strategic integration of STEM disciplines, authentic practices in the STEM workforce and integrating technologies to support such STEM practices.

Assessing Chemistry Teachers' Change Process while Implementing Technology: The Concerns-based Adoption Model
Orit Herscovitz, Technion-Israel Institute of Technology
Gabriella Shwartz, Technion-Israel Institute of Technology
Shirly Avargil, Bar Ilan University
Yehudit Judy Dori, Technion-Israel Institute of Technology
ABSTRACT:
In the last ten years the Ministry of Education in our country have promoted a reform that supports meaningful learning in which one aspect is the integration of technology for conceptual understanding. In this paper, we selected the Concerns-Based Adoption Model as a theoretical framework for examining the concerns and change process teachers experience while integrating an innovative Technology-Enhanced Learning Environment (TELE). An analysis of two case studies, one of high school and the other of middle school chemistry teachers, helped us to obtain an in-depth understanding about the way teachers adopt an innovation. Analysis revealed that after ten years of technology implementation high school teachers regressed from the advanced stages of concern to the earlier ones. Examining middle school teachers showed that teachers experienced different concerns that are characterized by different process of change. Our research suggests a specific dimension for analyzing a process of change by profiling and characterizing science teachers concerns with different qualification, experience, and in diverse settings, and dealing with it as a group and as individuals. This characterization might help develop specific interventions and activities for different groups of science teachers based on specific concerns while implementing TELE.

Middle School Science Teachers' Technology Decision for Inclusive Science Classrooms
Alexis A. Rutt, University of Virginia
Frackson Mumba, University of Virginia
Vivien M. Chabalengula, University of Virginia
Laura K. Ochs, University of Virginia
ABSTRACT:
This study explored middle school science teachers' technology decisions for inclusive science classrooms. A sample comprised 75 middle school science teachers in different school districts. Data was collected using a Technology Decision for Inclusive Science Questionnaire. Results show that teachers selected instructional technologies for inclusive science classrooms. None of the teachers listed assistive technology. Results also show that students' learning disabilities were not among the factors that influenced teachers' technology selection for inclusive science classrooms. Most teachers lacked knowledge of technology integration in inclusive science classes, and had moderate confidence in integrating technology in inclusive science classes. Although science teachers' technology decisions were within the framework that integrates practical classroom knowledge for regular classes, such decisions are unlikely to promote effective science teaching and learning in inclusive classrooms. These findings have implications on science teacher education and science teaching in inclusive classrooms.

Teacher Perceptions of Educational Technology in Schools across Rural Nepal

Emilie Coppinger, University of New Hampshire
Sameer Honwad, University of New Hampshire

ABSTRACT:

Today, K-12 classrooms across the world are equipped with technologies that promise higher student engagement, more access to content knowledge and more effective learning. Teachers all around the world often find use of technology in the classroom intimidating because leveraging tools not designed to fit the needs of the classroom can cause disruption. While there is recognition that technologies have the potential to effect positive change in classrooms across the developing countries there is very little research available on how teachers are coping with the technology that is being introduced into the classrooms across the developing countries. Given this need to understand how teachers in developing nations are using technology to teach subject matter to their students we designed a research study in rural Nepal that focuses on teachers attitudes and beliefs toward use of technology in their classrooms. As a part of the study we decided to focus understanding what are some of the information communication technologies (ICTs) that are being used across schools in rural Nepal and what is the attitude of teachers in rural Nepal, toward ICTs that are being used in their schools?

Strand 14: Environmental Education
Students' Ecological Conceptions
2:30pm-4:00pm, Hyatt Travis AB
Presider: Lucinda N. Sohn, Texas A&M University

Conceptual Change in Natural Resource Management Students' Ecological Literacy
Anne Marie A. Casper, Colorado State University
Meena M. Balgopal, Colorado State University

ABSTRACT:

Conceptual change in capstone courses provides unique opportunities to examine how students draw from multiple university courses and experiences to resolve conceptual confusion. We examined how natural resource management students revised their conceptions of 'ecosystem' throughout their capstone course. The concept of ecosystem may seem simple, but it is complicated by a lack of shared meaning across disciplines. Our study was grounded in both socio-cultural and conceptual change theories to explore how students' conceptualizations of the relationships between natural, ecosystem, human, and human artifact influenced their conceptions of ecosystems. Students who did not describe ecosystems as natural struggled much less with an integrated human-ecosystem conception than those who described ecosystems as natural. We conclude that it is important to explicitly create shared meaning of key conceptions at the start of a capstone course to facilitate shared meaning-making and desired conceptual change during the course.

Investigating Student and Teacher Perceptions of the Intersection between Daily Life & Ecology
Yael Wyner, City College of New York
Erica Blatt, College of Staten Island

ABSTRACT:

This study used sociocultural learning theory to better understand how middle and high school environmental science and biology students and pre and in-service science teachers connect the daily life activity of eating to food web concepts learned in school. We sought to understand how student and teacher perceptions of the environment and their experiences influenced their responses to interview questions regarding this topic. Findings, based on transcribed interviews with 54 study participants, indicate that three quarters of participants were unable to connect the food they eat with ecosystem food webs. Even so, many respondents particularly those from the elite public schools, did not demonstrate common food web misconceptions, instead showing a sophisticated understanding of food webs. These findings indicate that even though participants are proficient in their school science understanding of the ecological concept of food webs, they do not readily think about how their everyday out-of-school activities, like eating, relate to this concept. This result may be representative of a more general disconnect between formal ecology instruction and daily life activities. We provide several recommendations for how this disconnect can be remedied in our classrooms.

How Problem Features Interact with the Ways that Seventh Graders Frame Agency in Ecological Problems
Megan P. Cuzzolino, Harvard University
Michael S. Tutwiler, Harvard
Eric W Torres, Harvard Graduate School of Education
Tina Grotzer, Harvard University

ABSTRACT:

Notions of agency play a key role in human cognition. Biases toward agentive, intentional, and teleological explanations have implications for science education, especially because students' intuitions are often misaligned with accepted scientific explanations. When generating hypotheses about scientific phenomena, assuming simple, purposeful agentive causes may lead students to overlook causal explanations that involve complex interactions, as well as those in which the behavior of an agent leads to unwitting or unintended consequences. This is particularly problematic for learning about environmental issues which may entail agency that is distributed across many actors and over long periods of time. This study explored how students evoked agency and intentionality in their explanations for ecological phenomena on two different scenarios that have different inherent problem features. The first was

related to an eutrophication scenario in a pond. The second scenario was related to impacts of acid rain on a forest. Students were much more likely to cite agentive causes in the pond scenario than the forest. However, the described intentionality of the agents' behavior was considered unaligned/unintentional for the pond and aligned/intentional for the forest scenario. The paper considers implications for pedagogy and the design of research instruments and methods.

Design and Evaluation of an Advanced Undergraduate Course on Sustainable Energy for Science Majors
Elon Langbeheim, Weizmann Institute of Science
ABSTRACT:
This paper describes the basic tenets of a sustainable energy course for university science majors. The main objective of the course is to provide tools for evaluating ways in which energy can be produced and utilized with minimal greenhouse gas emissions. The course uses a quantitative approach for analyzing an emission-free energy plan and the local environment as a central context. The description of the course is followed by an exploratory study, describing the knowledge and attitudes of students who completed it. The findings indicate that most students were able to correctly respond to factual questions but were less able to do so in quantitative ones or in questions that elicit understanding of physical laws.

Concurrent Session #9
4:15pm – 5:45pm

Strand 1: Science Learning, Understanding and Conceptual Change
Understanding Students Conceptions about Science
4:15pm-5:45pm, HBG Convention Center 006D
Presider: Michael Kamen, Southwestern University

Challenging Notions of Stable Cognitive Biases in Undergraduate Biology Students
Julia S. Gouvea, Tufts University
Matthew R. Simon, Tufts University
ABSTRACT:
Stable, deeply entrenched patterns of intuitive thinking called 'cognitive biases' have been proposed as major impediments to accurate biological reasoning. Recent research suggests that these underlying biases (aka cognitive construals) could account for the tendency in students to agree with biologically inaccurate statements. An alternative explanation is that students do not intend to agree with the construal content of these statements, but rather, their agreement is the result of noticing valid biological relationships. If students are truly committed to construal-based thinking, then contextually cueing their attention to the specific construal content of a statement should not influence their agreement with that statement. However, if students do not intend to agree with the construal, then specifically cueing their attention to it should result in increased disagreement with the statement. We conducted a survey study with undergraduate biology students and found that students' agreement with construal statements decreased when they were cued to specifically consider the construal. We also found evidence that students were considering multiple kinds of biologically appropriate relationships in their written responses, calling into question the prevalence and stability of construal-based thinking in undergraduate students and the presence of underlying of cognitive biases.

Design of Remedial Module to Overcome School Students' Misconceptions in Biological Sciences
Narendra D. Deshmukh, Homi Bhabha Centre for Science Education
ABSTRACT:
The paper presents the design of the study to understand misconceptions, method of developing remedial material and field testing. In summary, my approach to examining students' conceptions and designing modules on various biological concepts will be helpful to students for rectification of misconceptions and support teachers for identification and designing teaching strategies. The learning experiences will not only yield a deeper basic understanding of the processes of students' conceptions, but also illuminate the designing of effective remedial modules. This research has an inbuilt component of evaluation and dissemination. The remedial modules developed to address students' misconceptions in biological sciences in collaboration with the many science teachers in the various country will be tried in schools of various contexts. From this study teachers should learn to see patterns in the range of students' thinking about specific science topics and to design remedial module on above mentioned approaches which may help students refine their understanding.

Longitudinal Learning Dynamics and the Conceptual Restructuring of Evolutionary Understanding
Xiaoying Wang, Stony Brook University
Jesse Colton, Stony Brook University
Gena C. Sbeglia, Stony Brook University
Stephen J. Finch, Stony Brook University
Ross H. Nehm, Stony Brook University
ABSTRACT:

Although a large body of work in undergraduate biology education has revealed important insights into student learning difficulties about natural selection using pre-post multiple-choice tests, much less work has explored longitudinal learning patterns using rich measures of conceptual understanding (such as those derived from constructed response assessments). Our study explores longitudinal learning patterns about natural selection in a large introductory biology course. We used two approaches to characterize students' longitudinal performance patterns: (1) Sankey plots and (2) Trajectory analyses. We collected students' written responses to two ACORNS assessment items at five timepoints throughout the semester and scored their key concepts, naive ideas, and reasoning model types for different evolutionary contexts (animal and plant, trait gain and loss). Classes from 2015 (n = 360) and 2016 (n = 440) were studied. We found that (1) student performance patterns were not uniform within classes or throughout semesters, (2) performance gains achieved early in the course in some cases declined later (and, in some cases, rebounded), and (3) significant performance gains continued to occur long after targeted instruction. Our results suggest that pre-post testing can obscure important learning dynamics central to understanding how instruction impacts student learning.

What Makes a Misconception Robust to Change
J. Bryan Henderson, Arizona State University
Elon Langbeheim, Weizmann Institute of Science
Michelene T. H. Chi, Arizona State University
ABSTRACT:
This paper serves as an update to the ontological shift view of conceptual change that pertains to certain robust misconceptions. These misconceptions do not stem from a confusion between entity and process ontologies, but rather, are rooted in the ontological categorization of different types of processes that learners may be more or less familiar with. Robust misconceptions are resistant to targeted instruction if a schema with the appropriate ontology is not available to the learner. Pointing to a "narrative-like," Direct Schema that develops from our familiarity with storytelling and everyday scripts, we argue that learners are more apt to intuit a concept with a sequential ontology for processes than they are an emergence ontology for processes. This updated framework does not presuppose that student thinking is an inflexible set of ideas, or that students cannot shift back and forth between different ontologies, as has been interpreted by others. Rather, the main thrust of our updated framework is that tapping misconceptions without establishing a clear distinction between appropriate and inappropriate ontologies can inhibit students' ability to accept the refined notions. We provide examples in which this important sequential/emergent distinction may help overcome notoriously robust misconceptions in the sciences.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Argumentation Interventions
4:15pm-5:45pm, HBG Convention Center 007A
Presider: Annemarie Palincsar, University of Michigan

Enhancing Scientific Argumentation through Infographic Authoring
Joseph L. Polman, University of Colorado, Boulder
Joanna Weidler-Lewis, University of Colorado, Boulder
ABSTRACT:
Argumentation is an essential feature of science practice. This paper examines how an activity system involving science news infographics authoring afforded students opportunities to engage in scientific argumentation, and the ways in which the activity supported students' developing more sophisticated scientific argumentation and engagement with contemporary scientific debates. The data come from an NSF funded project designed to foster young people's ability to search for, critically assess, and represent STEM information through the authoring of infographics. We found that the iterative process of creating visual representations of scientific information encourages the basic elements of argumentation including constructing, supporting, and critiquing claims, and that having opportunities to receive constructive feedback on this authoring process by peers, community members, and experts further develops the practice of argumentation embedded within the context of related epistemic practices.

How Does Argumentation from Experimental Data and Observations Influence Learning in School Science Labs?
Burkhard Priemer, Humboldt University of Berlin
Tobias Ludwig, Humboldt University of Berlin
Doris Lewalter, Technical University of Munich
ABSTRACT:
Argumentation from data and evidence evaluation are widely seen as scientific core practices. Consequently, science educators have become aware of these topics, especially in the past two decades. However, until recently, little research has analyzed the influence of personal factors such as content knowledge, need for cognition, situational interest, and personal relevance, in students' argumentation from experimental data and observations. Furthermore, there is a gap in the research regarding the influence of argumentation on learning outcomes through experimentation in school labs. This paper seeks to demonstrate there is a relation between personal factors and argumentation, as well as a relation between argumentation and learning outcomes by presenting the findings from a study among 938 secondary school students in a lab work setting. Results reveal a strong relationship between content knowledge and favorable types of argument from the perspective of science education. In addition, this paper identifies arguments which lead to longer lasting

learning outcomes through experimentation. This study contributes to a better understanding of argumentation from data and observations in school labs and learning of science through experimentation.

Technology-enabled Real-time Scaffolding for Improving Secondary School Students' Written Scientific Argumentation about Complex Systems
Hee-Sun Lee, The Concord Consortium
Amy Pallant, The Concord Consortium
Ou Lydia Liu, Educational Testing Service
ABSTRACT:
Seamless integration of scientific argumentation into classroom teaching is essential but difficult to achieve. Most needed is a mechanism by a more knowledgeable other to scaffold students while they are constructing a scientific argument. We developed an automated feedback system that (1) diagnoses students' arguments through an automated scoring engine based on natural language processing algorithms, (2) is programmed to provide students with tailored feedback matching students' current performance, and (3) is built on a software architecture that connects students' computer monitors, a curriculum server, and an automated scoring engine server within a very short time frame, i.e., less than five seconds. We embedded the feedback system in an online curriculum module teaching climate change. This study addresses how students improved their scientific arguments when this automated feedback system was fully deployed in real time.

The Impact of the Design and Use of Multiple Models on Scientific Curricular Argument
William J. McConnell, Virginia Wesleyan College
Daniel L. Dickerson, East Carolina University
Stephen R. Burgin, University of Arkansas
Petros Katsioloudis, Old Dominion University
ABSTRACT:
Design-based instruction is receiving much attention in current science education literature. Although some aspects of scientific argumentation are often included in well-known design-based instructional methods, it is not always a primary focus. The purpose of this study was to better understand how design-based instruction with an emphasis on scientific modeling might impact students' modeling-based argumentation abilities. In the following mixed-method multiple case study, seven, seventh-grade students attending a secular private school in the United States underwent a design-based modeling instructional intervention involving students in designing multiple models including 3D printed models. Pre/post data were collected through the use of interviews. Other data included student artifacts in the form of models, notes, exit tickets, and video recordings of students throughout the intervention. Argument was analyzed using the Instrument for the Analysis of Scientific Curricular Argument. Interviews and all other data were coded and analyzed for emergent themes. Findings included increased persuasion during argument in early stages of the modeling process as compared to modeling-based educational contexts, patterns in the way students used specific model forms in argument, and patterns in participants' transformational reasoning using different models. Practical implications and recommendations for further research are also presented.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
K-12 Engineering Research
4:15pm-5:45pm, Hyatt Presidio ABC
Presider: Catherine Quinlan, Howard University

How Should an Engineer Talk? Exploring the Language Demands of Engineering in an Elementary Classroom
Justin McFadden, University of Louisville
ABSTRACT:
The integration of engineering and science standards is a defining feature of the Next Generation Science Standards. The language demands and needed supports to scaffold student discourse during engineering design challenges is a notable area to focus on given the importance of promoting academically productive discourse in elementary classrooms. Research to date has yet to fully explore and explain this phenomenon beyond noting that it is important to promote student-to-student discourse during integrated learning experiences. Exploring the emergence of this integration on the micro-level is appropriate and valuable (Bloom et al., 2004). In this study, a 4th grade teacher and four of his students took on a novel engineering design challenge. Discourse analysis (Gee, 2001) and elements of adequate description (McDermott, Gospodinoff, & Aron, 1978) allowed for unique interpretations of student and teacher discourses in action during the design, construction, and redesign of a mining extraction tool. Results indicated that giving students access to the building materials prior to and during the design stage are a potential scaffold that can afford extended opportunities for students to engage in engineering thinking and discourse. Lastly, engineering talk moves are presented as a teacher support that should be further examined in elementary settings.

Is Engineering just an Application of Science and Mathematics? Investigating the Relation between Engineering, Science and Mathematics Competencies Empirically

Carolin Frank, University of Leipzig

ABSTRACT:

The Next Generation Science Standards released in the United States in 2013 ask science teachers to address both science and engineering content and processes in school curricula and assessment. It is expected that the inclusion of engineering in K-12 classrooms can lead to improved learning and achievement in science and mathematics. The underlying assumption of these expectations is that engineering activities meaningfully integrate science and mathematics content. Although the NGSS standards and theoretical papers state that engineering, science and mathematics competencies are highly related, there is almost no empirical evidence. The aim of the presented study is to investigate the relation between engineering, science and mathematics competencies. These competencies were surveyed by several tests. These tests were administered to a sample of N= 1.349 students, who just started a vocational training. The findings suggest that engineering competencies include science and mathematics competencies unique aspects in addition.

Multimedia Notebook Cards in Support of Engineering Design Practices and Disciplinary Discourse in Elementary School

Kristen B. Wendell, Tufts University
Chelsea Andrews, Tufts University

ABSTRACT:

As an increasing number of U.S. elementary schools offer their students formal engineering learning experiences, questions arise about which kinds of instructional supports to adopt along with engineering curricula. We conducted a qualitative case study that asked, how do elementary students respond to multimedia "notebook cards" designed to help them participate in the language and literacy practices of collaborative engineering design? This study emerged from the first implementation of our Multimedia Notebook Cards, which consists of a set of PowerPoint slide masters loaded onto iPad Minis. These intentionally designed templates seeded students' digital notebook pages during a windmill design challenge. Data sources included field notes, digital notebooks, and video recordings of six student teams across two fifth-grade classes at a diverse urban elementary school. Microethnographic analysis revealed that the cards and related classroom structures supported student work in three ways: a) the cards served as boundary objects that mediated productive student interactions with each other, teachers, and design ideas; b) these interactions supported student participation in engineering design practices and c) deepened their awareness of the disciplinary Discourse of engineering design. This work provides a concrete example of how an intentional support for engineering language unfolded in the classroom.

Undergraduate Early Childhood Educators and Engineers Interdisciplinary Toy Design Collaboration: A Perception and Interaction Study

Amy Trauth, University of Delaware
Jennifer Gallo-Fox, University of Delaware
Lynn Worden, University of Delaware
Jenni Buckley, University of Delaware

ABSTRACT:

In order to be able to successfully teach engineering in the classroom, preservice teachers need to be proficient with engineering design processes. Furthermore, working collaboratively on interdisciplinary teams affords engineering students with opportunities to develop skills critical to successful product development. The purpose of this study was to the extent to which, if any, a semester long toy design project influenced the perceptions of early childhood education and engineering students on one another's fields of study. Students worked on interdisciplinary teams to design, construct, and test toys for young children. Pre- and post- surveys were responses were subjected to statistical analyses. Results indicate both early childhood education and engineering students held fairly high views of one another's professions prior to the course, but engineering students reported greater interest in child development after the course than early childhood students reported with regard to engineering. Collaboration resulted in a slight decrease in the perceptions of the ability of both groups' interpersonal skills and communication. This study extends research on beneficial collaborations between educators and scientists by extending into the field of engineering. Results from this work informs preservice teacher education by adding to collective understanding of the contexts for professional learning.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Socio-scientific Issues in Science Education
4:15pm-5:45pm, HBG Convention Center 007B
Presider: Malcolm S. Pringle, Boston Public Schools

Development of a Socio-scientific Issue Curriculum Unit for Middle School Students: Genetically Modified Foods

Mustafa S. Topcu, Yildiz Technical University

ABSTRACT:

Normal 0 false false false EN-US JA X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin:0in; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:12.0pt; font-family:Cambria; mso-ascii-font-family:Cambria; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin;} Socioscientific Issues (SSI) based teaching has been presented as an effective approach to create meaningful

learning environments in science classrooms. However, one of the essential reasons for the limited use of SSI based instruction in school contexts is lack of well designed SSI based curriculum materials. The aim of this study is to develop a SSI based unit of instruction for use in middle school science. The unit focused on genetically modified foods as a context for student exploration of biotechnology. In this study, we used a design based research method that has produced SSI curriculum materials and research findings. In this study, we used a design based research method that has produced SSI curriculum materials and research findings. The design product is a five week unit that we developed in the spring of 2016. This study designed and developed a successful SSI based unit of instruction, beginning with a focal issue, interacting with science ideas and practices, and ending with a culminating activity. The SSI unit design process showed the potential of using an SSI approach to implementing Turkish middle school science curriculum. Future research may focus on designing and development of new SSI based instructions for different science units and grade level of students. Normal 0 false false false EN-US JA X-NONE

Evolution of a Model for Socio-scientific Issue Teaching and Learning
Troy Sadler, University of Missouri
Patricia J. Friedrichsen, University of Missouri, Columbia
Jaimie Foulk, University of Missouri
ABSTRACT:
Socio-scientific teaching and learning (SSI-TL) has been suggested as an effective approach for supporting meaningful learning in school contexts; however, limited tools exist to support the work of designing and implementing this approach. In this paper, we draw from a series of four design based research projects that have produced SSI curriculum materials, research findings, and design insights. The paper describes the creation and evolution of a model for SSI-TL. The model highlights a sequence of learning experiences that should be featured in SSI-TL and the kinds of learning objectives that should result. Student learning experiences should include encountering a focal SSI; engaging in science practices, disciplinary core ideas and crosscutting concepts as well as socio-scientific reasoning practices; and synthesizing key ideas and practices through a culminating exercise. The proposed learning objectives align with Next Generation Science Standards and also reflect the important social dimensions of SSI.

Impact of Socioscientific Issues on Middle School Students' Character and Values for Global Citizens
Wardell A. Powell, University of Massachusetts, Amherst
Dana L. Zeidler, University of South Florida
ABSTRACT:
The purpose of this investigation was to determine the extent to which socioscientific issues instruction on animal cloning impacted middle school students' abilities to use ecological worldview, social and moral compassion, and sense of socioscientific accountability to determine the permissibility of animal cloning. The students' abilities to use character and values as they engaged in dialogue and debates to make decisions on SSI were investigated with a Character and Values as Global Citizens Assessment survey developed by Lee et al., 2013. Participants were 77 seventh-grade students enrolled in five Comprehensive Science courses, taught by the same teacher, at a middle school in the southeastern region of the United States. Non-parametric two-tailed Wilcoxon analyses were used to determine differences between the students' pre and post-Likert responses. Results indicated that the lesson significantly impacted students' social and moral compassion ($Z = -2.505$, $p = .012$) and socioscientific accountability scores ($Z = -2.381$, $p = .017$). In contrast, the lesson did not demonstrate a positive impact on students' ecological worldview ($Z = -1.185$, $p = .236$). Qualitative analyses revealed several interesting trends and themes. For example, students in favor of cloning overwhelmingly used interconnectedness to express support for the cloning of animals.

Exploring the Relationship among Middle Grade Teachers' Conceptions of STEM and Equity
Matthew Kloser, University of Notre Dame
Jessica Gottlieb, Texas Tech University
Matthew Wilsey, University of Notre Dame
Gina N. Svarovsky, University of Notre Dame
Patrick Kirkland, University of Notre Dame
Jessica Puricelli, University of Notre Dame
ABSTRACT:
STEM education occupies a prominent role in educational discussions, but its principles have been applied in a variety of ways that serve local needs. The lack of a common conception of STEM may result in not only a lack of coherence in execution, but also in raising obstacles to equitable engagement of STEM. This study explores middle grades science, math, and technology teachers' conceptions of STEM education, how this does or does not differ from disciplinary practice, and how issues of equity and obstacles to equity exist in their formal STEM learning contexts. Results from interviews across twenty-two schools and thirteen states indicate that the integration of disciplines and the presence of problem-based learning focused on authentic problems are key characteristics of STEM education. However, teachers in the sample conceptualized a wide variety of STEM characteristics that may lead to incoherence in implementation across contexts. Furthermore, teachers identified several pedagogical characteristics that can promote equity in STEM classrooms, but failed to recognize pedagogical or curricular obstacles to engaging all students in STEM.

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

Learning Assistant Programs and Teaching Assistant Professional Development
4:15pm-5:45pm, HBG Convention Center 007C
Presider: Claudia P. Aguirre-Mendez, Emporia State University

"Tell Me Why": Eliciting and Responding to Student Ideas in an Undergraduate Biology Laboratory Course
Anna M. Strimaitis, Florida State University
Sherry A. Southerland, Florida State University
ABSTRACT:
Recommendations for postsecondary biology education describe how effective science instruction engages undergraduates in the practices and discourses of science to learn science. Biology lab teaching assistants (TAs) are increasingly responsible for enacting such instruction, and to do so with minimal teacher preparation. This research describes how 5 undergraduate TAs enacted the ambitious practice of eliciting and responding to student ideas when teaching the same 4 laboratory investigations during their first and second semesters of being a TA for a general biology laboratory course for nonscience majors. Our findings indicate that all 5 TAs elicited more student explanations than student factual responses or observations during at least one of the eight investigations. Those participants who engaged with the established instructional supports, such as observing a peer and reflecting on video clips of own teaching, were more successful at consistently eliciting student explanations than those who did not engage with these supports. Probing and pressing follow up questions were essential for eliciting student explanations, while asking a series of display questions or responding to student contributions with a mini-lecture were barriers. All participants had difficulty responding to unanticipated student contributions in productive ways. Implications for professional development are discussed.

Learning Assistant Practices through the Lens of Students: Micro-interactions and Impacts on Students' Metacognition in STEM College Classrooms
Hagit Kornreich-Leshem, Florida International University
Rocio Benabentos, Florida International University
Zahra Hazari, Florida International University
Geoff Potvin, Florida International University
Idaykis Rodriguez, Florida International University
Laird Kramer, Florida International University
ABSTRACT:
With increased efforts to engage women and underrepresented minorities in STEM, our project focuses on the impact of Learning Assistants (LA) in collaborative STEM college classrooms on student success and intent to pursue a STEM career. Learning Assistants are undergraduate students who help facilitate student learning and encourage students to articulate their ideas and reflect on their learning. By doing so, LAs are an integral part of a student-centered reformed classroom. This correlational study uses an epidemiological approach to examine the extent to which classroom interactions with LAs influence students' metacognitive awareness. LA practices under examination include frequency of interactions, type of conversations between LAs and students, discussion facilitation, and conditions that broaden student participation. This study constructed predictive models that take into account individual student behaviors and out-of-class experiences, thus isolating the effect of in-class student interactions with LAs. We found that student experiences in a STEM college classroom relate to students' metacognitive awareness through individual learning experiences, group learning experiences, and interactions with Learning Assistants. Based on previous studies on shared-mediated metacognition, we suggest that small groups may create a collaborative zone of proximal development with the guidance of a Learning Assistant.

The Relationship between Enacting Ambitious Instruction and Developing Sophisticated Conceptual Frameworks of Biological Knowledge
Anna M. Strimaitis, Florida State University
Sherry A. Southerland, Florida State University
Brittany Kraft, Florida State University
Carolyn Schultz, Florida State University
ABSTRACT:
Biology teaching assistants (TAs) are now responsible for implementing ambitious instruction with minimal teacher preparation. However, teaching responsibilities are often not considered opportunities to develop as a professional research scientist. A small amount of evidence suggests that engaging students in effective science instruction actually plays a role in developing TA science proficiency. This research explored this link by investigating how 5 TAs develop the ambitious practice of eliciting and responding to student ideas during their first semester of teaching and the relationship between developing that practice and developing a more sophisticated conceptual framework for biological knowledge. We administered a previously published Biology Card Sort task to the TAs at the start and end of the semester to capture changes in knowledge organization. We videotaped TAs eliciting and responding to student ideas during four lab investigations evenly spaced across the semester, transcribed the whole class conversations, and coded TA talk for ambitious discourse moves and student talk for rigor of scientific explanations. The three participants who consistently elicited student explanations over the semester also developed more expert conceptual frameworks for biological knowledge than the two participants who did not consistently elicit student explanations.

Undergraduate Facilitators for Active Learning in Organic Chemistry: The Outcomes of the Experience
Hannah E Jardine, University of Maryland
Lee a Friedman, University of Maryland
ABSTRACT:
In this study, we describe the development of a course to educate and prepare undergraduate "facilitators" for small group problem solving sessions in a large introductory undergraduate organic chemistry course. We then explore the outcomes of the entire experience for one cohort of facilitators through qualitative analysis of written reflections, surveys, and field notes. Our findings suggest the new course achieved its goals of providing facilitators with effective teaching techniques and reinforcing content knowledge, and it created a forum for the facilitators to provide feedback to each other and to the course instructor. Furthermore, the new course catalyzed the development of professional skills, enhanced metacognitive abilities, reinforced the benefits of active learning, and exposed facilitators to educational literature. These findings are noteworthy because they demonstrate the effectiveness of a new model for the preparation and education of undergraduate facilitators for problem solving sessions in large chemistry courses.

Strand 6: Science Learning in Informal Contexts
Science Learning in and about Nature - A
4:15pm-5:45pm, HBG Convention Center 006B
Presider: Patricia Patrick, Consultant

A Targeted Literature Review of Field Trips in Outdoor Settings
James F. Ammons, University of Georgia
Barbara A. Crawford, University of Georgia
ABSTRACT:
Science educators have used field trips to enhance classroom instruction for many years. This targeted literature review explores what is known about P-12 (ages 4 – 18) field trips taken to outdoor settings. Based on the recommendations from both the science education and environmental education literatures, this review takes a specific look at the collaboration between classroom educators and the educators who work at outdoor sites in order to evaluate the level of collaboration during the planning and carrying out of the field trip. This review also explores the demographics of who has been studied during each field trip. Results show limited strong collaboration between classroom teachers and outdoor educators while still highlighting some positive examples. Results from the comparison of demographics reveal a need for researchers to take more care in fully describing actual participants.

Bioinspiration at the Zoo: Synergy between Science Education and Environmental Education in an Informal Context
Michal Topaz, Technion
Tali Tal, Technion
ABSTRACT:
Former research points to a gap between science and engineering education (SEE) vs. environmental education (EE). In this study, we used bioinspiration (or: biomimicry) as an interdisciplinary approach comparing biological challenges to engineering problem and implementing ecological principles to solve human challenges using sustainable designs. This qualitative-interpretative study was held at the zoo, with adult participants, voluntarily enrolling in a bioinspiration educational program. We asked what scientific ideas do adult participants identify in bioinspiration activities? And what relationships between science, engineering and the environment they find following the bioinspiration program at the zoo? Data were collected using in-depth interviews, with adult participants who completed the full program. We initially used categories, derived from the NGSS crosscutting concepts and disciplinary core ideas in life science for data analysis, and continued with categories, emerging from the data through constant comparative analysis. We found that participants identified some scientific ideas and pointed out the relationship between science, technology and the environment. We believe that bioinspiration education at the zoo provides an opportunity for synergy between SEE and EE in everyday life. Our study is a step toward developing adult informal science programs in general, and more specifically, informal bioinspiration education.

Informal Science Learning in Formal Contexts: Children Help to Save Endangered Falcon
Dafna Gan, Seminar Hakibuzim, Northeastern University
Adiv Gal, Kibbutzim College
ABSTRACT:
The informal science education program (ISEP) at a formal elementary school, pseudo-named Falcon School (FS), encouraged the fifth-grade students to help and protect an endangered falcon for almost two decades. This long-term ISEP based on informal learning processes has never been formally evaluated. This qualitative case study investigated the features of this long-term ISEP, which emphasized place-based education (PBE) pedagogy. The PBE program has focused on solving scientific environmental problems through a variety of strategies—especially through science experiential and outdoor learning—that increase science skills, environmental awareness, and connectedness. We analyzed documents, focus group transcriptions, and individual interviews. Our findings aligned with the goals of both the ISEP and values beliefs norms (VBN) theory variables as well as indicated four main features: leadership and vision, resources, nature-connectedness, and nature conservation. These features work collectively to make FS's culture and long-term ISEP distinct. FS's scientific culture was present across the entire organization, including its rules and

rituals, which in turn allowed it to expand to communities around the school. This study contributes to existing scholarship by identifying five features that need to be incorporated to enhance informal science education.

Strand 6: Science Learning in Informal Contexts
STEM Pathways and Pipelines with Informal Learning Settings
4:15pm-5:45pm, Hyatt Travis AB
Presider: Jennifer L. Weible, Central Michigan University

Staying in Science: An Examination of Pathways of Youth Who Participate in Immersive Science Research Activities
Preeti Gupta, American Museum of Natural History
Karen Hammerness, American Museum of Natural History
Timothy Podkul, SRI International, Inc.
ABSTRACT:
In this paper we describe findings from a longitudinal study that aims to contribute to a broader understanding of why the pathways of underrepresented youth who have a deep interest and aptitude in science in high school do or do not pursue or complete science studies in college and beyond. This paper also describes how providing these youth with formative authentic science experiences can support their science persistence toward future STEM pursuits. The study focuses on approximately 900 urban youth participating in, or alumni of, an intensive program that offers mentored science research experiences to high school students.

STEM Career Choices and Science Leisure-learning Interests
Gina Childers, University of North Georgia
Gail Jones , North Carolina State University
Katherine Chesnutt, North Carolina State University
Elysa N. Corin, Harvard-Smithsonian Center for Astrophysics
Thomas Andre, Iowa State University
ABSTRACT:
Understanding factors related to leisure STEM learning and STEM career selection is key to create effective interventions and career education that can increase the numbers of students who enter the STEM workforce. The 2864 participants in the study were adult hobbyists that included birders, astronomers, gardeners, model builders, rock/fossil collectors, insect collectors, home brewers, beekeepers, inventors, and environmental monitors. Participants completed a survey about their levels of hobby participation, motivation to participate in the hobby, perceived benefits of participating in the hobby, influences to continue to continue to engage in the hobby, reported influences on career choice influences, and perceived science identity. Results showed hobbyists with STEM careers were significantly more likely than those without STEM careers to indicate that competition, recognition, aesthetics/artistic appreciation and being creative were factors that influenced their hobby interests. STEM career hobbyists were more likely to report seeing themselves as a scientist and identifying with people with STEM careers when they were in school than the non-STEM career hobbyists. The STEM career hobbyists' reported influences on their career choice suggest that career choices are driven by self-efficacy, outcome expectations, involvement in a STEM hobby, and interests.

The Effect of Repeated Attendance in STEM Outreach Programs and Other Factors on Pipeline Persistence
Alonzo B. Alexander, North Carolina State University
Osman Aksit, North Carolina State University
Eric N. Wiebe, North Carolina State University
ABSTRACT:
The demand for STEM (Science, Technology, Engineering and Mathematics) workers in the U.S. continues to outstrip the number of STEM graduates produced domestically. This requires an understanding of why older students choose to remain or leave the STEM pipeline. Using data from the XXXX Project, two dependent variables related to persistence were studied: intent to major in STEM and intent to attend an in-state college—on a sample largely consisting of underrepresented minorities (URMs). A logistic regression was used to assess the factors related to these variables. The results indicated that dosage, or the number of times a student engages in STEM outreach, had a negative association with intent to major in STEM. Intent to attend an in-state college was positively associated with STEM major intent. Additional results showed that while dosage had no effect on the intent to attend an in-state college, gender, along with student interest in life science-related fields, were positively associated to in-state attendance. These results indicate a need to think more broadly about factors related to STEM pipeline persistence.

The Effects of Integrated STEM Experiences on Student Confidence in STEM
Jeanna R. Wieselmann, University of Minnesota
ABSTRACT:
Five nonprofit organizations in a Midwest metro area formed a partnership to provide elementary students with a more cohesive STEM experience and thereby increase students' long-term interest, learning, and achievement in STEM. Previous findings indicated that students experienced a decrease in confidence in their STEM abilities following participation. The purpose of the present study was to gather in-depth, qualitative information to further investigate students' experiences in an effort to better understand what

contributes to their decreasing confidence. The study sought to answer the research question: How do a set of integrated STEM experiences affect students' confidence in STEM domains? Small group interviews were conducted with a total of 44 students and analyzed for patterns, three of which emerged. First, the partner experiences made students feel smarter and more confident about their content knowledge. Second, students recognized they still have a lot to learn about STEM. Finally, the challenges associated with doing STEM cause mixed feelings related to student confidence in STEM. The discussion focuses on reconciling the finding that students feel smarter, yet experience a decrease in confidence in their STEM abilities. Recommendations are made for fostering student confidence in applying their knowledge in a STEM context.

Using Research to Practice Partnerships to Develop Ecosystem-wide, Customized Interventions to Sustain Youth STEM Interest
Nancy Staus, Oregon State University
Lynn D. Dierking, Oregon State University
John H. Falk, Oregon State University
Jennifer N. Wyld, Oregon State University
ABSTRACT:
The decline in youth attitudes, interest, or motivation to learn science, technology, engineering or math (STEM) during early adolescence (i.e., the "leaky pipeline" phenomenon) is an enduring problem in the United States and elsewhere. A recent longitudinal study of adolescents in a low-income urban school district revealed that youth identified with three distinct STEM Interest Profiles: STEM Interested, Math Disinterested, and STEM Disinterested. These results suggest that educational interventions which are customized in ways that meet the unique needs of youth in each profile may be more successful in developing and sustaining STEM interest than generic one-size-fits-all solutions. Here we describe a participatory research and design effort focused on understanding how STEM interest develops and how STEM educators (in school and outside) can work collaboratively to support interest development and maintenance. This 5-year project builds on the previous study by utilizing the research findings described above to collaborate with educational partners in the community to develop customized, connected and coordinated learning interventions. The goal is to empower the community to envision and create a more effective and synergistic community-wide STEM education system that recognizes the rich STEM learning opportunities that already exist in most communities.

Strand 7: Pre-service Science Teacher Education
Preparing Teachers for Underserved Youth
4:15pm-5:45pm, HBG Convention Center 007D
Presider: Alison R. Miller, Teachers College, Columbia University

Coherence and Connections: The Educational Value of Content Storylines in Learning to Develop Science Curricula
Catherine E. Milne, New York University
Robert Wallace, New York University
Fabienne Doucet, New York University
ABSTRACT:
In this presentation, we explore the affordances of a content storyline approach to learning to build curriculum as part of science methods courses. We argue that a storyline approach uses a language structure and function that, because of its global reach, is familiar to students and supports coherence and integration of content while allowing temporal and curriculum space for culturally relevant pedagogy.

Impact of Engagement of Candidates with Urban Youth on Views about Learners and Teaching Practices
Gail Richmond, Michigan State University
ABSTRACT:
Recently there has been a call for meaningful clinical experiences and greater emphasis on practices for those preparing to become teachers. This study examined such experiences on candidates' views of students' learning capacity, on leveraging interests and experiences in instructional planning, and on development of candidates' identity as science teachers. As they accumulated experiences working with youth in an urban school and then in a summer enrichment program, their skills at designing NGSS-aligned lessons improved significantly, and their insights concerning students' lives, their responsibility to be responsive to their needs and interests, and the purpose of science learning, developed in complexity. A consistent theme was the importance of feedback received from instructors and peers on development and implementation of plans. These findings support prior work suggesting that what matters for beginning teacher retention is pedagogical training and the opportunity to regularly teach, assess and receive feedback for instruction prior to starting one's career. Also suggested by these data is the importance of engaging with students who can inform candidates' understanding of those they will teach, in contexts similar to those they will work in, and to analyze teaching efforts to revise and improve instructional plans.

Sociopolitical Understandings and the Structure-Agency Dialectic in Science Teacher Preparation
Daniel Morales-Doyle, University of Illinois, Chicago
Maria Varelas, University of Illinois, Chicago
David Segura, University of Illinois, Chicago

Carole P. Mitchener, University of Illinois, Chicago
Marcela Bernal-Munera, University of Illinois, Chicago

ABSTRACT:
This study investigates the sociopolitical understandings of pre-service secondary science teachers in an urban-focused MEd-plus-licensure program. While this topic does not receive much attention in the literature, it has the potential to inform practices and policies to better prepare science teachers for schools that are characterized by inequity. This qualitative study involved 10 pre-service high school science teachers. Data sources included their work from several courses (including student teaching), their written reflections on 8 workshops facilitated by community partners, and three reflective conversations with one of the co-authors. The pre-service teachers' sociopolitical understandings varied across three dimensions: lenses, contexts, and time. Different opportunities to explicitly consider the structures that undergird inequity in science education alongside reflection on experiences in urban schools supported the pre-service teachers to develop new analytical lenses, to apply existing frameworks to new contexts, and to sharpen their understandings over time. The findings show that the development of these understandings ebb and flow throughout program structures which may support the development of teachers' hope, agency, and commitment as they enter "high need" schools. These findings highlight the need for longitudinal research on the sociopolitical views of science teachers as it relates to their persistence and retention.

Using a Science as Inquiry Model to Prepare STEM Teachers in High Need Areas
Paige K. Evans, University of Houston
Cheryl Craig, Texas A&M University
Donna W. Stokes, University of Houston

ABSTRACT:
In urban centers in the United States, it is difficult—if not impossible—to fill secondary science positions with teachers who have the requisite content area knowledge, skills and dispositions. To remedy this situation, a new model of science teacher education has been designed. This model attracts science major students into the teaching profession through early field experiences in high need schools and the offering of potential internships and scholarships. The science majors are then prepared in a state-of-the-art teacher education program steeped in the principles of teaching science as inquiry. This paper elucidates this approach to secondary science teacher preparation and shows how the particular model addresses pernicious teacher attrition and retention issues in urban school districts serving predominantly high needs, minority youth.

Strand 7: Pre-service Science Teacher Education
Video Analysis and Preservice Teacher Learning
4:15pm-5:45pm, Hyatt Republic ABC
Presider: Ron Gray, Northern Arizona University

"I'm So Proud of My Progress!": Targeted Video Reflections to Support Reform-Oriented Science Teaching
Julianne A. Wenner, Boise State University
Julie M. Kittleson, University of Georgia

ABSTRACT:
Improving elementary science education involves helping teachers understand how to implement current recommendations about science instruction. The question, then, becomes how to assist teacher candidates (TCs) in developing the skills to support students in achieving the goals laid out in reform documents. Because we cannot assume that there will be opportunities to observe reform-oriented science in the field, we created the Supported, Collaborative Teaching Model (SCTM) to focus TCs' attention on key aspects of science teaching. In our latest iteration of the SCTM, we included focused video reflections on questioning and discussion techniques that support reform-oriented science. Our findings indicate that through the use of focused video reflections, TCs made great strides over the semester in terms of the quality of their questions, their discussion techniques, and supporting student participation. TCs saw first-hand the power of thoughtful questions and discussion in supporting students' progression towards constructing explanations and providing evidence for those explanations. The combined power of the SCTM and video reflections prepares TCs to "learn from teaching" and have opportunities to hone their skills as well as engage in reform-oriented science that they may not have otherwise in the field.

Examining the Impact of Lesson-analysis Based Teacher Education across Methods Courses, Student Teaching, and Induction
Christopher Wilson, BSCS
Molly Stuhlsatz, BSCS
Connie Hvidsten, BSCS
Betty Stennett, BSCS

ABSTRACT:
An ongoing line of research at [XXXX] examines the impact of video-based analysis of practice professional development programs for science teachers. A series of research and development projects have studied the STeLLA professional development model – Science Teachers Learning from Lesson Analysis, and have focused on elementary teachers, online PD, high school teachers, scale-up and sustainability, and in this study, pre-service teacher education. In this project we took the STeLLA framework, tools, and

resources and designed a variation intended for elementary preservice teachers. The ViSTA Plus program (Videocases for Science Teaching Analysis Plus) includes a semester-long analysis-of-practice methods course introducing preservice teachers to STeLLA strategies and video-based lesson analysis. We studied the ViSTA Plus program in partnership with two universities. We compared the experiences of preservice teachers through student teaching and then through their first-year teachers in the ViSTA Plus program, to a group of teachers who experienced a traditional teacher education program and induction experience. Results show that teachers in the ViSTA Plus program developed significantly greater science content knowledge than teachers receiving Business-as-Usual teacher education, and this difference resulted in greater science content knowledge in their students during student teaching.

Notice and Note: Exploring Pre-service Teachers' Science Instruction through Video Analysis
Heather J. Johnson, Vanderbilt University
Teresa K. Dunleavy, Vanderbilt University
Melanie Hundley, Vanderbilt University
ABSTRACT:
Learning how to leverage student thinking to make instructional decisions requires a shift in how pre-service teachers think about teaching. With an explicit goal to attend to student thinking, we explored the characteristics of clips pre-service science teachers selected to illustrate student thinking and how they attended to student thinking in a video club context. While initial clips were teacher-centered and lecture-based, over time, more clips captured student-centered classrooms. Furthermore, through sustained engagement with video clubs, pre-service teachers increasingly attended to student thinking, often unpacking evidence from student talk or work with respect to their diverse ideas. This work provides evidence that video clubs allow a context for pre-service teachers to analyze science instruction that centralizes student thinking in practice.

Tracking Student Teachers' Changing Ability to Notice in a Video-based Biology Methods Course
Kennedy Kam Ho Chan , The University of Hong Kong
Jessica Shuk Ching Leung, The University of Hong Kong
Tracy Cuiling He, The University of Hong Kong
Dirac Sze Him Lam, The University of Hong Kong
Richard Chi Keung Ng, The University of Hong Kong
ABSTRACT:
The ability to notice is a key component of teacher expertise. Yet, there are limited studies on how to foster student teachers' (STs') ability to notice in initial science teacher education course. This study presents an empirical investigation of how STs' ability to notice changed and the critical learning experience causing such changes in a year-long video-based biology methods course. STs were asked to write down what they noticed when watching a lesson video before and at the end of the course. The comments were analyzed with respect to what the STs noticed and how they interpreted what they had noticed. A rubric comprising seven dimensions was devised to differentiate STs' ability to notice. Findings suggested that STs' ability to notice was improved after attending the course and that STs showed more advancement in certain dimensions (e.g., attending to more critical features of the classroom, adopting a more interpretive stance) than other dimensions (e.g., providing more specific description, relating their observations to specific science ideas). Analysis of interview transcripts and written reflection illuminated the critical learning experience that had influenced the STs' ability to notice. Implications on how to enhance teachers' ability to notice are discussed.

Strand 8: In-service Science Teacher Education
Teachers' Communities of Practice & Collaboration
4:15pm-5:45pm, HBG Convention Center 008A
Presider: David F. Jackson, University of Georgia

Crossing Boundaries: The Role of Assessment as a Boundary Object in Professional Development
Marcelle A. Siegel, University of Missouri, Columbia
Suleyman Cite, University of Missouri, Columbia
Christopher D. Murakami, University of Missouri, Columbia
Nilay Muslu, University of Missouri, Columbia
Shannon Burcks, University of Missouri
Kemal Izci, Yuzuncu Yil University
ABSTRACT:
Our study focused on high school teachers and professional developers participating in a community-centered professional development (PD) program focused on classroom assessment. We employed a communities of practice framework to situate the research. The research question asked what role assessment tools played as boundary objects across communities. Two years of data collection included transcripts of collaborative meetings, online records of assessment development and discussion, records from classroom observations, and final assessment products. Data were analyzed by multiple researchers to identify emergent themes. Results presented in three vignettes showed how assessment tools acted as boundary objects across: 1) teacher and professional developer communities, 2) professional developer and student classroom spaces, and 3) teacher and student communities. We described challenges and practices related to assessment tools as boundary objects and demonstrated ways they were re-interpreted.

The findings of the study are unique, as they offer examples for setting up shared assessment-related goals and language among teachers and researchers to transform a very difficult practice (assessment!).

Science Teachers' Collective Sensemaking: A Conceptual and Analytic Framework to Understand Implementation of Reform Practices
Sara Heredia, The University of North Carolina, Greensboro
ABSTRACT:
Implementation of reform practices in science is a localized and complex process that teachers work through with their colleagues and their students over time. In the process of implementation, various dilemmas arise for teachers and they need time and space to work through those dilemmas as they construct responses to reform. Specifically, teachers need to make sense of how reform practices differ from their current practices and how they align with the organization of teaching and learning at their school and district. In this paper, I provide a conceptual and analytic framework to identify the resources teachers leverage to make sense of those dilemmas and how they do or do not construct possible pathways toward implementation. I present findings from a case study of one team of biology teachers' interactions during professional development meetings over three years. Major shifts in the organization of the school and district influenced the types of dilemmas and the ways in which teachers went about making sense of the innovation of the professional development each year of the study. Findings suggest the importance of localized design of professional development to understand the dilemmas that arise for teachers and to support them in addressing those dilemmas.

Teacher Professional Development and Communities of Practice. Insights from Eight Case Studies
Francesco Cuomo, Martin-Luther-Universität Halle-Wittenberg, Germany
Emilio Balzano, Università degli Studi di Napoli Federico II, Italy
Ciro Minichini, Istituto Nazionale di Documentazione, Italy
Serpico Marco, Università degli Studi di Napoli Federico II, Italy
ABSTRACT:
Two key elements in promoting quality science teaching in schools are the development of Communities of Practice and effective teacher professional development. We present findings from a comparative analysis of case studies which provide insights both these two issues and how the interaction with external experts (researchers in science communication in our case) can influence them. The case studies are based on participatory researcher-teacher collaborations in Italian schools over one year in contexts as different as low and high income areas, small provinces and large cities in southern and northern Italy. Teachers in our case studies felt that they can largely benefit from cooperation with colleagues and with external experts and were generally deeply aware of the opportunities implied in the process. The way collaboration is intended, however, seems crucial. A 'culture of cooperation' is needed in order for collegial moments to be exploited meaningfully. Significantly, the interaction with an external expert seems to catalyze meaningful cooperation when the approach adopted is participatory. In this case, teachers develop a sense of ownership of the programme and are more likely to shape content and structure according to their needs and interests and make the best of the experts' contribution.

Teacher of an Integrated STEM Language
Mary M. Capraro, Texas A&M University
Robert M. Capraro, Texas A&M University
Ali Bicer, Texas A&M
Niyazi Erdogan, Balikesir University
Ayse T. Oner, Texas A&M University
ABSTRACT:
Teachers should develop the extremely important 21st century skill of precise and accurate communication. Precision with STEM oral language is crucial. Emphasis on precise oral with language along with increased spatial skills with modeling can improve the possibilities of success in STEM courses and STEM career choices. Fourteen middle and high school teachers who were engaged in a week of professional development (PD) were the participants. The Aural/Spatial Interactions and Invariant Components of Vocabulary for STEM Content Area Specialists (AS-STEM) was administered to these participants to determine how STEM discourses influenced AS-STEM success. This study compared language differences among groups that were more versus less successful at representing an unseen 3-D object by drawing 2-D depictions from oral descriptions. Those demonstrating greater success were able to create depictions with more accuracy and used coherent and precise language and shared meaning. Thus, teachers who merged language types using precision and jointly took ownership were more successful. This collaborative task engagement helped develop a sense of importance for precise language and hopefully this realization will translate into teachers encouraging students to work cooperatively and to complete tasks using precise language.

Strand 10: Curriculum, Evaluation, and Assessment
Related Paper Set: Supporting Three-Dimensional Science Learning and Instruction
4:15pm-5:45pm, HBG Convention Center 006C
Presider: David L. Fortus, Weizmann Institute of Science
Discussant: Norman Lederman, Illinois Institute of Technology
ABSTRACT:

The Framework for K-12 Science Education and the Next Generation Science Standards present a vision for science learning and teaching that expands upon traditional notions of what it means for students to know and do science. By specifying three dimensions of science learning – science and engineering practices (SEPs), disciplinary core ideas (DCIs), and crosscutting concepts (CCCs) – these documents emphasize that the learning and instruction of science should focus the use of these three dimensions in making sense of a broad range of phenomena and to find solution to problem. This new emphasis requires curriculum and assessment designers, and teachers to reconsider the ways in which they design curriculum and assessments and enact instruction. The four papers in this theoretical paper set address four prominent issues that teachers need to address to successfully incorporate three-dimensional learning and instruction in their classrooms: (A) putting phenomena at the center of instruction, (B) supporting intra- and inter-unit coherence, (C) integrating all three dimensions when assessing student learning, and (D) adapting classroom norms to support student engagement.

The Centrality of Phenomena in Three-Dimensional Learning and Instruction
Joseph S. Krajcik, Michigan State University
Tom Bielik, Michigan State University
Jeffrey Nordine, IPN, Kiel
Knut Neumann, Leibniz Institute for Science Education, Kiel
David L. Fortus, Weizmann Institute of Science
Norman G. Lederman, Illinois Institute of Technology

Instructional Coherence as a Support for Three-Dimensional Science Teaching
Jeffrey Nordine, IPN, Kiel
Sebastian T. Opitz, Michigan State University
Knut Neumann, Leibniz Institute for Science Education, Kiel
David L. Fortus, Weizmann Institute of Science
Joseph S. Krajcik, Michigan State University
Norman G. Lederman, Illinois Institute of Technology

Assessing Three-Dimensional Learning
Knut Neumann, Leibniz Institute for Science Education, Kiel
Marcus Kubsch, Leibniz Institute for Science and Mathematics Education, Kiel
David L. Fortus, Weizmann Institute of Science
Joseph S. Krajcik, Michigan State University
Jeffrey Nordine, Leibniz Institute for Science and Mathematics Education, Kiel
Norman G. Lederman, Illinois Institute of Technology

Supporting Student Engagement in Three-dimensional Learning and Instruction
David L. Fortus, Weizmann Institute of Science
Israel Touitou, Weizmann Institute of Science
Joseph S. Krajcik, Michigan State University
Jeffrey Nordine, Leibniz Institute for Science Education, Kiel
Knut Neumann, Leibniz Institute for Science Education, Kiel
Norman G. Lederman, Illinois Institute of Technology

Strand 11: Cultural, Social, and Gender Issues
Cultivating Science Teacher's Sociopolitical Consciousness
4:15pm-5:45pm, HBG Convention Center 008B
Presider: Tanja Tajmel, Humboldt-University Berlin

"That Study was Racist": A Critical Cross-Case Analysis of Sociopolitical Consciousness Raising in Secondary Science
Manali J. Sheth, Iowa State University
ABSTRACT:
This critical qualitative cross-case analysis uses teaching episodes from two secondary science teachers to conceptualize the practice of sociopolitical consciousness (SPC) raising in the context of science teaching and learning. The analysis provides insights into how teachers can develop their own and their students' SPC for science learning. Tensions in working towards sociopolitical consciousness raising this practice are also outlined.

Comparing Secondary Science Teachers' Culturally Relevant Unit Plans Before and After an Equity-Focused Induction Course
Paula S. Rozowa, University of Minnesota
Julie C. Brown, University of Minnesota
Felicia Leammukda, University of Minnesota

ABSTRACT:
With the purpose of supporting secondary in-science teachers in attaining culturally relevant science instruction in their classrooms, this case study investigates how beginning in-service secondary science teachers participating in an equity-focused induction course adapted their own existing science units to make them culturally relevant for their students. We used two data sources: the original and final curriculum units constructed by participating teachers. Both drafts of each teacher's science unit were deductively coded according to the *Culturally Responsive Instruction Observation Protocol* (CRIOP) (Powell & Rightmyer, 2011) to determine their level of cultural relevance. All participating teachers increased the culturally relevant connections from original to their final, modified unit lesson plans in several notable ways. For example, none of the initial curriculum submitted contained sociopolitical consciousness, then each of the final curricular units expressed sociopolitical consciousness through class projects The increased cultural relevance varied among participants from an "add-on" that seems out of place to reflective weaving together of the existing curriculum and culturally relevant themes. In a short amount of time, three weeks, beginning science teachers were successful in the modification of their own curriculum to be more culturally relevant for their students.

Exploring Changes in Science Teachers' Attitudes Toward Culturally Diverse Students During an Induction Course
Preethi Titu, University of Minnesota
Elizabeth A. Ring, University of Minnesota
Julie C. Brown, University of Minnesota
Gillian H. Roehrig, University of Minnesota
ABSTRACT:
In recent decades, schools in most Western countries, including the United States, have become increasingly culturally diverse and as global migration continues to rise, cultural diversity in schools will continue to grow worldwide. Though an expansive research base has shown that teacher beliefs and attitudes play an important role in student performance, little is known about science teachers' attitudes about cultural diversity or about teaching culturally diverse students. The purpose of this study was to explore how the attitudes of science teachers toward teaching culturally diverse students were influenced by a 4-week-long induction course which focused on equitable science teaching. We analyzed two primary data sources: teacher responses to an attitude-eliciting card-sort activity during the first and last weeks of the course, and semi-structured interviews after each card-sort activity. Findings indicate that teachers felt more prepared to work with their culturally diverse students, seemed to understand that the power shift in the classroom is beneficial to the students' learning and recognized the richness of information that diversity can provide to a classroom. In this presentation, implications for the preparation of equitable science teachers will be discussed.

Influences of Science Students' Epistemic Reflections on their Socio-political Actions
John Lawrence Bencze, University of Toronto
Mirjan Krstovic
ABSTRACT:
Many jurisdictions have urged educators to engage students in decision-making regarding socioscientific issues — such as debates about climate change. Scholars argue, however, that students also need to take socio-political actions — such as lobbying of power-brokers — to address issues. Experience indicates, however, that such a tack in formal schooling often meets structural barriers. Nevertheless, there is evidence to suggest student motivation to act can be enhanced (in some contexts) when they self-direct research they use to inform their actions. In the study reported here, we concluded — based on constant comparative analyses of qualitative data — that, in addition to being engaged in apprenticeship activities, involving students in (implicit and explicit) cycles of reflections on the nature of research ('science') and actions ('technology') and possible application of such reflections in action project work can increase students' expertise and motivation for self-directing research-informed and negotiated actions on socioscientific issues. In essence, increases in student autonomy in research-informed and negotiated actions can arise from increases in their levels of shared epistemic agency. Implications for promotion of socio-political actions through school science are discussed.

Strand 14: Environmental Education
Symposium: From Globalization to Glocalization: Developing Ecological Sociopolitical Consciousness in Science Education
4:15pm-5:45pm, Hyatt Travis CD
Presenters:
Sophia (Sun Kyung) Jeong, University of Georgia
Kimberly Haverkos, Thomas More College
Deborah J. Tippins, University of Georgia
Bhaskar Upadhyay, University of Minnesota
Shakhnoza Kayumova, University of Massachusetts-Dartmouth
Carolina C. Rodriguez, Australian Catholic University
Hyoungbum Kim, Chungbuk National University, Korea
Stacey Britton, University of Mississippi
Ryan M. Walker, Mississippi State University
Elizabeth Pate, University of Texas, San Antonio
ABSTRACT:

Precipitated by globalization, it is widely accepted that scientific and technological innovations are driven by a nation's need to gain economic competitiveness and prowess in the global market. Thus, changes in the sciences carry profound implications for the way science education is developed. Furthermore, an increased globalization of our world has brought neoliberal ideology into education where individual success, competition, and standardization have become the primary aims of science education. The authors of this paper challenge the dominant discourse in science education and the existing educational system by drawing upon the EcoJustice Theory to frame glocalization, and centering the development of sociopolitical consciousness at the core of how we think about science education and its value.

Concurrent Session #10
8:30am – 10:00am

Administrative Sponsored Session
Admin Symposium: How Effective is Education for Sustainable Development at School? Findings from Recent Studies across Europe
8:30am-10:00am, HBG Convention Center 006C
Presenters:
Anna Uitto, University of Helsinki, Finland
Jelle Boeve-de-Pauw, University of Antwerp, Belgium
Niklas M. Gericke, Karlstad University, Sweden
Daphne Goldman, Beit Berl Academic College, Israel
Dorit Baum, University of Haifa, Israel
Teresa Berglund, Karlstad University, Sweden
Daniel Olsson, Karlstad University, Sweden
Peter Van Petegem, University of Antwerp, Belgium
Seppo Saloranta, University of Helsinki, Finland
Bell Weiss, University of Haifa, Israel
ABSTRACT:
Despite the increasing implementation of sustainability education (SE) within formal education, information on its effectiveness is scarce. This symposium presents findings from empirical studies with quantitative and mixed-method designs that explore the impact of SE in primary and secondary education in Sweden, Belgium, Israel, and Finland. The studies reveal nuanced and not always positive impact of SE. Swedish students' sustainability learning outcomes (SLO) were slightly higher for some students but lower for others when certified SE schools are compared to reference schools. Israeli students' SLOs and school's environmental-performance were higher in schools that advanced to higher accreditation-level ('ongoing-green') while achievements in basic-level-accredited ('green') schools were lower than in reference schools. The eco-school program in Belgium increased specific SLOs (mainly knowledge), but also it fostered controlled motivation rather than autonomous motivation for acting sustainable way. However, the Finnish study found that through sustainability self-efficacy, pro-environmental values and norms, in-school pro-social and agency experiences are able to enhance students' SLOs. Overall, despite widespread implementation of whole-school SE-programs, their educational effectiveness requires improvement. The symposium will address the importance of focusing on educational and school-organizational processes that foster student' SLOs, and argue for SLO assessment as an integral component of SE-program implementation.

Research Committee Sponsored Session
Admin Symposium: Positioning Indigenous Knowledge Systems in the Glocalization and Sustainability of Science Education Research and Practice
8:30am-10:00am, HBG Convention Center 006A
Presenters:
Femi S. Otulaja, University of the Witwatersrand
Meshach Mobolaji Ogunniyi, University of the Western Cape
Irene U. Osisioma, California State University, Dominguez Hills
ABSTRACT:
While science has done much good, recent effects of global climate change, such as, environmental pollution, habitat destruction, excessive flooding and drought, increasing desertification and non-sustainable environmental practices have brought attention to the damaging effects of the scientific and industrial revolution perpetrated by Eurocentric science. The inability of science to solve a litany of human problems, such as, disease resistance, food shortage, human hunger and poverty, depleting biodiversity in the rain forests, oceans and seas have brought an increased awakening for a need to integrate indigenous knowledge into the science curriculum. Increased migration of indigenous people into the western world have increased the notion that non-mainstream indigenous students do not perform well in the science classroom. Within indigenous people, the bringing of western science into indigenous science classrooms without decontextualizing it to accommodate indigenous peoples' ways of thinking, knowing and doing, perpetrates the notion and stereotyping, even by western-educated science teachers, that indigenous students cannot "do" science. Ogunniyi (1998; 1996; 1997; 2004; 2007a & b; 2008a & b; 2013a & b; 2014), has been in the fore front of efforts to integrate Science-IKS education and Otulaja (Amosun et al., 2013; Mpofu et al., 2013; 2014; 2015; has been working with Ogunniyi on these issues. Otulaja & Ogunniyi (2016) are calling for the decontextualizing of science and science education by acknowledging the contributions of indigenous knowledge (IK) to Western science and by accepting IK as an authentic body of knowledge that will benefit humanity through its integration into science, technology, engineering and mathematics (STEM) education in the classroom.

Presenters, Femi Otulaja, University of Witwatersrand, South Africa Meshach Ogunniyi, University of Western Cape, South Africa
Presiders: Irene Osisioma, California State University Dominguez Hills, Carson, California Leon Walls, University of Vermont, Burlington, Vermont.

Strand 1: Science Learning, Understanding and Conceptual Change
Unraveling Genetics and Genetic Variation
8:30am-10:00am, HBG Convention Center 006D
Presider: Sebastian T. Opitz, Michigan State University

Identifying the Relationships between Constructs in a Genetics LP
Moraima Castro, Rutgers University
Ravit Golan Duncan, Rutgers University
ABSTRACT:
Genetics is an important topic in the biology curriculum. However, students seem to have great difficulties learning genetics. Learning progressions are theoretical models that describe learning of key ideas over extended periods of time. An important aspect of the work on revising learning progressions involves the understanding how the big ideas of a progression develop over time and what are the relationships between multiple constructs that comprise a learning progression. In this proposal, we present an analysis of the relationships between three constructs of a learning progression in genetics. The analyses of relationships between constructs are based on analysis of post interview data obtained from fifty-five 11th grade students who, prior to the interviews, engaged in a four-week unit that addressed these concepts in genetics. Our findings seem to indicate that progress along construct A influences progress in the classical constructs (E and F). Moreover, these findings seem to give more evidence of complexity of the relationships between constructs in an LP and how these can inform instruction. Understanding of the relationships between constructs allows us to better determine the ordering of topics during instruction.

A Human(e) Genetics Education: Teaching about Human Genetic Variation Can Reduce Racial Bias amongst Adolescents
Brian M. Donovan, BSCS
Rob Semmens, Stanford
Phil Keck, The Live Oak School
Elizabeth Brimhall, Palo Alto Unified School District
K.C. Busch, Stanford Graduate School of Education
ABSTRACT:
Experiments demonstrate that racial bias can be activated when people are led to believe that human races are far more genetically dissimilar than they actually are. However, there is apparently no experimental research that explores whether the converse is true. That is, when people learn scientifically accurate information about the true extent of genetic variation across human races, which is around 4.5%, does it reduce bias? We explore this question. We randomized middle and high school aged students (N = 166) into separate classrooms to learn for an entire week either about the topics of: (i) human genetic variation and racial difference; or (ii) climate variation and climate change. Across two experimental replicates, we demonstrate that when students learn accurate information about genetic variation between races it causes an increase in knowledge of human genetic variation and a decrease in racial bias. Furthermore, we find that 21% of the reduction in racial bias is transmitted through student knowledge of human genetic variation. Implications for human genetics education are discussed.

Using Corn to Foster Elementary Students' Understanding of Plant Life Cycle, Inheritance and Genetic Variation
Devarati Bhattacharya, University of Nebraska, Lincoln
Erin Ingram, University of Nebraska, Lincoln
Cory T. Forbes, University of Nebraska, Lincoln
Tyler Wolken, University of Nebraska, Lincoln
Maranda Kegley, University of Nebraska, Lincoln
ABSTRACT:
This research study uses corn as a model system to inform and assess elementary students' conceptions about lifecycle, inheritance and genetic variation in lower elementary level (K-4). We observed that elementary students depend on their prior knowledge from everyday experience (Lewis & Kattmann, 2004), use their intuition and knowledge of kinship (Duncan et al., 2009, Springer, 1995) to support their knowledge about genetics and inheritance. While describing traits, students often alternate between organismic and population level and struggle in relating genetic traits on the level of an organism. Given the complex nature of genetics and the existence of very few studies contributing to information about student conceptions of genetics and variation at the lower elementary level, this study informs the development of a conceptual framework for genetics and inheritance at the lower elementary level (K-4).

Characterization of Argumentation Moves in a Genetics Modeling Assessment
Veronica L. Cavera, Rutgers University

Ravit Golan Duncan, Rutgers University
Rozaliya Seryapov, Rutgers University
Kira J. Belkin, Rutgers University
Clark A. Chinn, Rutgers University

ABSTRACT:
Argumentation is a critical component of the new vision for science education. Students with a mastery of argumentation are able to marshal evidence in support of their claims and critique competing claims. We discuss a study of high school biology students' written arguments during a novel modeling-based unit in genetics. Students were tasked with evaluating two competing models of the biological basis of an inherited disorder. One of the models presented the correct mechanism, while the other provided a compelling but incorrect mechanism. We provided students with six pieces of evidence. We characterized the moves students employed in their arguments (e.g. contrasting models, using evidence to support a chosen model, providing a rebuttal), as well as move sequences (argumentation patterns). We found that model selection was not a determining factor for move quantity but that students who chose the correct model had more instances of refutation. Students who chose the incorrect model were able to develop complex arguments with epistemic features (e.g. appealing to criteria of good models). We discuss how students operationalize these moves for the purpose of developing a compelling argument, as well as the relationship between move sequences.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Understanding Argumentation
8:30am-10:00am, HBG Convention Center 007A
Presider: Abdi M. Warfa, University of Minnesota

A Statistical Investigation of the Role of Students' Content Knowledge in Argumentation Performance
Jianlan Wang, Texas Tech University
Zahra Hazari, Florida International University
Geoff Potvin, Florida International University
ABSTRACT:
In response to the significance of argumentation in science education, scholars have made efforts to promote students' performance in argumentation from two perspectives: quality of arguments and engagement in argumentation. Students' content knowledge level is believed to be a significant factor affecting students' argumentation performance. Previous studies regarding this issue were mostly conducted through a qualitative approach. This study takes a quantitative approach to gauge the relationship between students' content knowledge and their argumentation performance. Eight argumentation items were designed and tested in a national survey study of introductory college physics students (N= 1694). The result validates five argumentation items and categories them into two constructs: perceived argumentation ability and agency. The multiple regression models indicate that students' content knowledge is not a significant predictor of either argumentation ability or agency. However, gender and physics career intentions are significant predictors of students' argumentation agency. Male students have higher argumentation agency than females. Likewise, students who intend careers in physics have higher argumentation agency than those who are less likely to intend such careers.

Development Pre-service Chemistry Teachers' Argumentation Skills in Implementing Science Writing Heuristic at Chemistry Laboratory Subject/Problem
Ceren Soysal, Middle East Technical University
Esra Sarici, Middle East Technical University
Mustafa Tuysuz, Yuzuncu Yil University
Selcuk Kilinc, Middle East Technical University
Esen Uzuntiryaki-Kondakci, Middle East Technical University
ABSTRACT:
The purpose of this study was to examine the development of pre-service chemistry teachers' argumentation skills during the argumentation-oriented laboratory course. A total of six pre-service chemistry teachers (PCT) (4 females and 2 males) who enrolled in Laboratory Experiments in Science Education course participated in the study. Science Writing Heuristic (SWH) was used both as a tool to provide students opportunity for engaging in scientific arguments and as a data collection instrument to track the development of students' argumentation skills. In SWH format, students discuss beginning questions, form groups, perform laboratory experiments, analyze and discuss results with other groups. In this approach students make their claims and support their claims with evidences gathered from their observations during experiments. Results showed that, argumentation is very useful for students writing their claim, support their opinions at group discussions and explain chemistry terms successfully. When we look at the mean scores of groups, we can see all three groups' mean scores increase as time passes. Keywords: science writing heuristic, laboratory, argumentation, pre-service chemistry teachers, chemistry eduation

From Unproductive to Productive: Understanding Productive Argumentation from the Perspective of the Epistemological Resource Network

Jeonghwa Lee, Seoul National University
Heui-Baik Kim, Seoul National University

ABSTRACT:
The purpose of this study was to explore the kinds of epistemological resources activated during small group argumentation and how these activated resources networks change in response to contextual cues based on students' argumentation practices. To accomplish this goal, ten argumentative lessons were developed in a photosynthesis unit. Data were collected from the lessons and from semi-structured interviews and analysed in terms of two areas: the argumentation practice of the focal group and the activation of epistemological resources based on the framework of Hammer and Elby (2002). The results of the analysis showed that the students' argumentation practices and epistemological resources network began to change from the fifth argumentative lesson. During the earlier lessons, the students sensed the activities as 'filling in the worksheet with right answers' and simply copied the responses of the group's most high-achieving student, while activating network resources of propagated, belief, acceptance and accumulation. However, during the later lessons, the students sensed the activities as 'constructing evidence-based claims' and began to show not only various justifications, but also rebuttals to counter-arguments, while activating network resources of constructed, understanding, acceptance, accumulation, formation and rebuttal. The contextual cues that caused this change were also identified in this study. According to these results, this study argues that the resources framework has more powerful lens for explaining students' context-sensitive practice than existing frameworks: developmental-, and beliefs-based frameworks do. Finally, this case study facilitated the development of a theoretical framework to identify ways to strengthen students' epistemological resources.

Learning to Argue in Elementary School over Time: Constructing Ways of Building Answers Using Evidence

Luiz Gustavo F. Franco , Universidade Federal de Minas Gerais
Danusa Munford, Universidade Federal de Minas Gerais

ABSTRACT:
We investigate classroom interactions to learn about how a teacher and 3rd graders construct practices that are related to evidence use in science lessons. The research design was guided by Interactional Sociolinguisics and Ethnography of Communication. Based on contextualization cues, we identified words related to actions in the context of evidence use – verbs that were emphasized by the participants during the interactions. Over time, there was a change in the use of words being associated with sure answers and going to indicate access to data used in the construction of answers. The results evidence the importance of participating in discussions about how to build answers at elementary school, when children are introduced to scientific practices.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Instructional Approaches and Student Outcomes
8:30am-10:00am, HBG Convention Center 007B
Presider: Mike Ryan, Georgia Institute of Technology

High School Biology Instructors' Implementation of Peer Instruction: A Study of Vertical Transfer

Grant E. Gardner, Middle Tennessee State University
Jennifer C. Parrish, Middle Tennessee State University
Leigh McNeil, Middle Tennessee State University
Tom Cheatham, Middle Tennessee State University

ABSTRACT:
This NSF funded DRK-12 project, Promoting Active Learning in Science (PALS), sought to facilitate and evaluate the transfer of Peer Instruction (PI) from undergraduate physics to high school biology classrooms. Participating high school biology teachers (n = 22) used PI over the course of two semesters. Teacher self-report data, classroom observations, and open-ended questionnaires revealed the motivation for using pedagogically-critical aspects of PI varied by instructor. Teachers often chose not to use PI because of concerns that materials were at too cognitively challenging for their students and numerous adaptations to the pedagogy were made that affected fidelity of the strategy. This presentation will focus on the adaptations necessary to successfully move PI into high school biology classrooms and how to help teachers differentiate PI without unknowingly omitting critical features that can lead to a reduction of pedagogical effectiveness.

Teachers' Perceptions of Integrating Computer Simulations into Science Instruction

Xiaoyang G. Gong, University of Maryland

ABSTRACT:
The purpose of this study was to examine Chinese teachers' perceptions of integrating computer simulations into their traditional classroom teaching. The comparative case study showed that five environmental factors (time, technology efficacy and attitude, classroom structure and equipment, effectiveness, supporting materials and professional development opportunities) influenced the implementation and thus shaped their pedagogical practices. Concretely, one teacher planned to apply the computer simulation module as the assessment tool after class while the other planned to use it as the demonstration tool in class. This study has important

implications for how educators and administrators could provide supports (e.g., resources, materials and opportunities) to improve Chinese teachers' instructional practices of integrating technology. Keywords: PhET simulation, science instruction, contextual factors

Using Expert Perspectives to Inform the Design of Instruction about Ecosystem Science Practices
Amy M. Kamarainen, Harvard
Tina Grotzer, Harvard University
Shari Jackson Metcalf, Harvard University
Chris Dede, Harvard University
ABSTRACT:
Reform efforts advocate for integrating knowledge and practices in science instruction. Application of this idea is particularly challenging in the context of ecosystem science due to logistical and conceptual challenges that teachers and students encounter when thinking about and implementing investigation and associated practices in ecosystems science contexts. To inform the design of instructional materials that would better support teachers and students in integrating scientific practices in ecosystem science learning experiences, we used semi-structured interviews to gather perspectives on practices (including experimentation) from ten ecosystem science professionals. We offer descriptive accounts of the themes that arose in these interviews, and in the final paper we will consider how insights from this work may be applied to the design of ecosystem science instructional materials to better support teachers and students in developing accurate perspectives on practices within ecological and ecosystems science.

Making Science Practice Visible in the Classroom: Characterizing Teachers' Classroom Practice Related to the NGSS
Allyson M. Rogan-Klyve, Central Washington University
ABSTRACT:
This study documents and characterizes teachers' classroom practice in light of the adoption and implementation of the NGSS in a K-12 school district. Classroom observations were conducted over a two-year period guided by the Practices of Science Observation Protocol (P-SOP) (Forbes, Biggers, & Zangori, 2013) to characterize the ways in which teachers provided students opportunities to engage in scientific practices. Findings discussed in this study include patterns of teachers' classroom practice as it relates to the inclusion of scientific practices, and the activity structures teachers used to facilitate student participation in scientific practices. Notable patterns include the prevalence of some dimensions of scientific practice, and the limited occurrence of other dimensions of practice. Additionally, some classroom activity structures were found more likely to be used by teachers to engage students in scientific practices than others. Implications of these findings regarding opportunities for teacher learning related to the NGSS are also discussed.

An Instructional Material for Teaching 'Life Cycle of Frog' to Visually Impaired Students
Seyda Gul, Ataturk University
Fatih Yazici, Ataturk University
Mustafa Sozbilir, Ataturk University
ABSTRACT:
The aim of this study is to design an instructional material for visually impaired students. Material was designed in accordance with visually impaired students' needs. Observation and interview were utilized as data collection tools to determine students' needs and effectiveness of instructional material. The sample studied in the needs analysis consists of six 6th grade students from Visually Impaired Middle School in the city center of Erzurum/Turkey. In the light of students' needs towards physical environment, instructional, learning and assessment and evaluation, 3D printer was used to design some parts of instructional material about 'life cycle of a frog'. Additionally, color and tactile contrasts and embossed parts were designed through need analysis data. As a result, it is considered this material help teachers in order to support education and also to contribute a better understanding of students due to the fact that it was designed in accordance with the curriculum, learning outcomes, students' individual needs and their cognitive level. Additionally, it is suggested this material should be developed and disseminated more accordingly to the visually impaired students 'needs.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Chemistry Learning
8:30am-10:00am, HBG Convention Center 007C
Presider: Stephen L. Thompson, University of South Carolina

Analyzing Predictors of Freshmen Content Knowledge Acquisition and Study Success in Chemistry
Daniel Averbeck, University of Duisburg, Essen
Elke Sumfleth, University of Duisburg, Essen
Eckart Hasselbrink, University of Duisburg, Essen
ABSTRACT:

Reducing student dropout rates by analyzing and accordingly fostering predictors of study success is becoming increasingly important especially with respect to STEM fields. Although a lot of studies examining predictors of academic achievement exist, only a few focus on chemistry as one subject within the STEM fields. Most of this research uses different cohorts, focuses on non-specific factors or on introductory courses of general chemistry. Usually, exam notes are used as the only outcome proxy, although knowledge acquisition seems to be a more relevant variable in this context. In our study, we examine the impact of affective, motivational and cognitive factors on knowledge acquisition as the central prerequisite for academic achievement in chemistry. Additionally, we investigate the interrelations of knowledge in several chemical sub-disciplines and how they relate to study success in the university entry phase. To this end, we surveyed 128 freshmen in Chemistry in a long-term study at a German university. Using multivariate regression analyses and structural equation modeling, the cause-effect relationships can be discussed in a mediated cross-lagged panel model. First results indicate that prior knowledge in general chemistry and mathematical abilities are the most important variables influencing content knowledge acquisition and academic achievement.

Exploring General Chemistry Students' Explanations for Differences in Ionization Energy
Ted M. Clark, The Ohio State University
ABSTRACT:
Having students construct explanations for natural phenomena and articulating that understanding allows them to participate in a core scientific practice and is an important aim of having students become scientifically literate. However, many students have difficulty articulating their claims and, when they do, often their ways of thinking about and explaining the natural world differ from those of a scientist. In this investigation students' text responses for a question asking them to explain ionization energy values for hydrogen in comparison to halogens and alkali metals were analyzed. Categories of responses centered on whether explanations included physical principles, like electrostatic attractions and repulsions, or heuristic reasoning favoring octets and reaching the stability of a noble gas. It was found that these heuristic explanations, which were more prevalent than ones based on physical principles, were commonly teleological. In addition, there was a modest correlation between a student's understanding of electrostatic principles and their including this information in their explanation. This work has implications for both improving the students' conceptual understanding of this topic, and also for improving the ability of General Chemistry students to construct explanations for natural phenomena.

Learning and Valuing in Two Context-based General Chemistry Courses
Hannah Sevian, University of Massachusetts, Boston
Deirdre Hugi-Cleary, Gymnase Francais de Bienne
Florence Wanjiku, University of Massachusetts, Boston
Jesse M Baldoria, University of Massachusetts Boston
Courtney Ngai, University of Massachusetts, Boston
ABSTRACT:
Context-based learning (CBL) approaches "bring the learning of science closer to the lives and interests of students and show how the use of contexts would improve their interest in science and therefore enhance their understanding" (Pilot & Bulte, 2006). In this study, expected outcomes of CBL (Gilbert, 2006) are compared for two large enrollment university general chemistry courses designed as Gilbert's Model 3 (context is provided by personal mental activity). In both courses, the chemistry content was the same (kinetic molecular theory), but the contexts differed. Condition 1 provided a focal event of same size balloons of different contents and weights, then transformed through whole-class kinesthetic activity as a human model of a gas. Condition 2 provided a focal event of anthropogenic climate change due to atmospheric carbon dioxide buildup, then transformed through students' use of molecular dynamics simulations to design gas separation methods for carbon capture. A secondary data analysis study compared what students learned about matter structure and dynamics, ways that students translated learned content to other contexts, and what they valued in their context-based work. Relationships among these are explored, and implications proposed for increasing fluid translation and ensuring that students benefit from multiple scales of valuing.

Qualitative Assessment of Service Learning in Chemistry II
Megan O. Mahoney, Emporia State University
Claudia P. Aguirre-Mendez, Emporia State University
Diane L. Nutbrown, Emporia State University
ABSTRACT:
The purpose of this study is to examine the impact of service learning in a general chemistry course. Service learning is a pedagogy that connects community service with academic course content and objectives. Service learning pedagogies have been carried out in chemistry at the college level. This study is particularly novel in that it combines qualitative methods with control design. It is a multiple-case study embedded within a one-semester Honors College General Chemistry II seminar. Findings indicate that the students developed more specific knowledge and appreciation of the community, skills relevant to future careers, and greater awareness of self and others. Implications of this pedagogy for chemistry teaching and learning are discussed.

Strand 6: Science Learning in Informal Contexts

Strand Sponsored Related Paper Session: Dissecting Design Principles that Mediate Impact on Youth Participating in Long-term OST Programs
8:30am-10:00am, HBG Convention Center 006B
Presider: Jennifer Adams, Booklyn College
Discussant: Preeti Gupta, American Museum of Natural History
ABSTRACT:
Over the past few years, many of the presentations and posters at NARST conferences have documented the STEM outcomes of youth who participate in long-term out-of-school time (OST) programs. In this related paper set, a collaboration based on research from four long-standing informal science education institutions, we aimed to advance this discussion by collectively dissecting programmatic design principles that contribute to these outcomes. Our analyses reveal several commonalities across institutions that contributed to impacts including: (1) belonging to a shared community or culture; (2) social networks or relationships with STEM professionals; and (3) long-term participation or consistent contact hours. In alignment with the conference theme, we also report data on how these programs help to develop scientifically literate citizens and to diversify the STEM workforce. Lastly, we identify unique programmatic design principles associated with the distinct features of each respective ISE institution. Collectively, the findings of this study provide valuable insights on how informal OST science programs can have on mediating STEM outcomes and on maximizing the benefits of youth participants.

Science and Youth Development in a Museum-based Out-of-school Time Program
Faith R. Kares, Museum of Science and Industry
Aaron Price, Museum of Science and Industry, Chicago

Longitudinal STEM Identity Trajectories
Roxanne M. Hughes, Florida State University

Youth Development through Employment, Enrichment, and Community
Priya Mohabir, New York Hall of Science
Katherine Culp, Education Development Center, Inc.

An ISE Program's Impact on STEM Major and STEM Career Outcomes
Bobby Habig, University of Notre Dame
Preeti Gupta, American Museum of Natural History
Jennifer Adams, Booklyn College, CUNY

Strand 6: Science Learning in Informal Contexts
Topics in Science Communication: Stakeholders and Strategies
8:30am-10:00am, Hyatt Crockett AB
Presider: Eli Tucker-Raymond, TERC

Automatic Jargon Identifier for Scientists Engaging with the Public and for Science Communication Educators
Tzipora Rakedzon, Technion-Israel Institute of Technology
Ayelet Baram-Tsabari, Technion-Israel Institute of Technology
Noam Chapnik, Holon Institute of Technology
Roy Yosef, Holon Institute of Technology
Elad Segev, Holon Institute of Technology
ABSTRACT:
Scientists are required to communicate science and research not only to other specialists in the field, but also to scientists and specialists from other fields, as well as to the public and policymakers. One fundamental suggestion when communicating with the non-specialist public is the avoidance of professional jargon. However, avoiding jargon is difficult for scientists, and unfortunately there is no standard or user friendly program to aid scientists in adjusting their written messages. In this project, we will present an up-to-date, user friendly program for recognizing and evaluating jargon in written texts based on a corpus of ~90 million words published in the BBC site during the years 2012-2015. This program was compared with other lists in the literature and is being tested on pre and posttest writing samples from 250 students from an academic writing course for graduate STEM (science, technology, engineering and mathematics) students. A pilot on 75 students indicated that graduate students are aware of the appropriate jargon in academic writing, and did clearly use less jargon in the popular as opposed to academic parts. This tool may aid scientists and those teaching them to communicate to recognize and correct their texts for better public engagement.

Comparing Engagement Formats to Motivate Local Community Public Climate Change Action
Kathryn Stofer, University of Florida

Lisa M. Lundgren, University of Florida
Makenna Lange, University of Florida
Vaughan S. James, University of Florida

ABSTRACT:
To encourage science-based decision making and motivate public action on climate change, meaningful science engagement beyond traditional one-way outreach is crucial. Yet current engagement efforts such as science cafés still fall short in moving beyond deficit-style information transmission. These events also have time and geographic limitations. We are building on the science café model and establishing the idea of live events that allow for audience participation in drafting discussion questions that shape the ultimate event topics and speakers as well as content for related exhibits. Based on results from intercept interviews and surveys, we are creating a museum exhibit on climate change's effects on allergies and water quality in the local area, as well as two live panel discussion that will be webcast and broadcast later for comparison. Our audience indicated a lack of knowledge of community-level actions they can take on these issues as well. We assess success by comparing audience surveys about behavior change intent and questions posed during the events to similar data from the exhibit. Ultimately, our research adds to the literature on public engagement through science-café-style events, comparing the in-person format with online and broadcast versions as well as a more traditional museum exhibit.

Learning Science from Youths: Adult Responses when Youths Share Science

Amie Patchen, Boston College

ABSTRACT:
This study examined youths as science information sources for the adults and communities in their lives. Lifelong science learning is necessary for informed decision-making on politically or personally relevant science-related topics (Falk & Dierking, 2010; Feinstein, 2010), but engaging broad and diverse audiences has proved challenging (Feinstein & Meshoulam, 2014; Nisbet & Scheufele, 2009). An unexplored avenue for engagement is youths sharing science information with their communities. This mixed methods study examined survey (n = 399) and interview (n = 22) data to understand adults' perceptions of and reactions to youths as science information sources. The results showed that youths elicited different responses than adult scientists, indicating youths may offer a unique contribution to the science learning of their communities.

Stakeholders' Views on Science Communication, Focusing on Channel Types

Zehavit Kohen, Technion
Yehudit Judy Dori, Technion

ABSTRACT:
Facilitating students' science literacy is at the focus of science education. Recent educational reports call for a shift from the formal model of knowledge acquisition that is based on teacher-student interaction, toward a model which involves communicating science through active engagement with other science stakeholders. The current research investigates views of science stakeholders, regarding three main aspects of science communication: its importance, types of communication channels, and ways scientific knowledge should be shared and constructed. Participants were 347 individuals, representing four stakeholder groups with diversified scientific literacy, ranging from low—social science students, through teachers and STEM students, to high—the scientists. Research tools included interviews and open-ended questionnaires for documenting and analyzing the stakeholders' views. Findings revealed classification of categories within each one of the three aspects and their specific value along the wide directionality spectrum, from one-way communication – the deficit model to two-way dialogue. Investigating the categories distribution among the various stakeholders for the communication channels aspect revealed that all the stakeholders indicated the open discussions category as the most favourable way to communicate science. The views of the various stakeholders can serve as a starting point for deepening the much needed dialogue between them.

Telling my Story from my Perspective: African American Girls' Informal and Formal STEM Learning Experiences

Natalie S. King, Georgia State University

ABSTRACT:
In this paper, I share the interpretations and perceptions of African American girls who participated in a community-based informal STEM program. Using narrative inquiry, participants generated detailed accounts of their informal and formal STEM learning experiences, and how they perceive themselves as African American girls in STEM amidst injustices related to their race, gender, and class. Critical Race Methodology informed this research to portray the dynamic and complex experiences of African American girls, whose stories have historically been silenced and misrepresented. The data sources for this qualitative study included individual interviews, student reflection journals, samples of student work, and researcher memos which were triangulated to produce six robust counterstories. Major findings revealed that the girls perceived race to have the greatest influence on their STEM learning experiences, and embraced storytelling as a form of empowerment. Furthermore, the community-based informal STEM program ignited interest in STEM learning through field trips and direct engagement in scientific phenomena that allowed the girls to become agentic in continuing their engagement in STEM activities throughout the year. Awakening the voices of African American girls casts light on the lives and challenges of girls of color as STEM learners – from their perspectives.

Strand 7: Pre-service Science Teacher Education
Socioscientific Issues and Preservice Teacher Learning
8:30am-10:00am, HBG Convention Center 007D
Presider: Sanghee Choi, University of North Georgia

Examining Teacher Development Toward Effective Inquiry Instruction
Jill Birren, Marquette University
Leigh Van den Kieboom, Marquette Univeresity
ABSTRACT:
This paper describes our reflection on a context of clinical-based teacher preparation in which novice pre-service teachers attempted to implement inquiry-based science instruction to help students make sense of genetic engineering. The setting of our reflection was a teacher preparation program, which engaged a small cohort of novice pre-service teachers in science methods coursework embedded in the classroom of a more experienced high school science teacher. We utilized developmental models of professional practice that have outlined the complexity inherent in professional knowledge to analyze video-recordings of the instructional practices of three teachers implementing a novice-designed unit plan. Through our analysis three key teaching practices emerged as fundamental to the vision of inquiry described in science education reform: (1) conceptual goals of the lesson, (2) questioning practices teachers enact, and (3) student-centered sense-making. Trajectories through which professional teachers develop advanced practices that support inquiry-based instruction are discussed.

Pre-service Teachers' Attitudes Toward Biotechnology Applications
Jonathan Chitiyo, Southern Illinois University, Carbondale
Vivien M. Chabalengula, University of Virginia
Frackson Mumba, University of Virginia
ABSTRACT:
This study examined pre-service teacher's attitudes towards biotechnology and its related processes. A sample comprised 88 pre-service science teachers at a university in the Midwest of the USA. Sixty and 28 of these students were enrolled in Introductory Science course and Advance Science Course, respectively. Data were collected using a questionnaire that had 15 statements on a Likert-scale, and an open-ended perception questionnaire. The Likert items required students to indicate whether each statement is acceptable, unacceptable, or were unsure. Both the Likert scale items and open ended survey required students to articulate their attitudes and perceptions about the use of microorganisms for specific processes, genetic modification of food/plants, genetic modification of human genes, and genetic modification of animals. The results revealed four major findings: participants held positive attitudes towards biotechnology processes in the following descending order: the genetic modification of food/plants, followed by use of microorganisms for specific processes, then genetic modification of human genes, and lastly genetic modification of animals; about 40% of the respondents were unsure about use of microorganisms for specific processes, genetic modification of human genes, and genetic modification of animals; there were no significant differences in attitudes regardless of the science course level, teaching subject major, and whether they had taken biology courses or not; and respondents' perceptions revealed that most of them positively perceived the use of biotechnology processes involving microorganisms, plants /food, and to some extent the modification of human genes, but greatly disapproved the genetic modification of animals. Implications for science teaching/learning and curriculum design are discussed. kylew 0 0 2016-06-30T15:48:00Z 2016-07-05T14:14:00Z 1 287 1617 UVa 47 26 1878 14.0 Print 0 false false false EN-US JA X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin:0in; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:11.0pt; font-family:Calibri;} KEY WORDS: Attitudes, Biotechnology, Pre-service teacher

Strand 8: In-service Science Teacher Education
Teaching in High-needs Schools
8:30am-10:00am, HBG Convention Center 008A
Presider: Malcolm S. Pringle, Boston Public Schools

Commitment to STEM Teaching in High Need Schools: The Role of Scholarship Incentives
Stacy Olitsky, Saint Joseph's University
ABSTRACT:
Many students in high-need schools lack access to qualified science and math teachers due to teacher turnover. In recent years there have been programs aimed at increasing the number of high quality STEM teachers by offering scholarships to candidates in exchange for their agreement to teach in high need schools for a few years. However, there has been concern that scholarship recipients might fulfill the terms and then leave for jobs in suburban districts, or leave teaching altogether. In order to investigate whether commitment

to high need schools is stable or fluid over time, and to explore implications for the recruitment of teachers for scholarship programs, this qualitative study follows the trajectories of four science and math teachers who received NOYCE scholarships. The results show that while aspects of dedication that emerge from personal experience may be stable, commitment is also contingent upon relationships with students, colleagues and administrators over time. In addition, the results affirm the value of recruiting scholarship recipients who have strong initial commitment. However, results also show that scholarships can be effective in recruiting and retaining qualified teachers without initial strong commitment, but with potential commitment that develops through relationships and sense of efficacy.

Evaluating the Impact of a Robert Noyce Scholarship Program on Science Teachers
Meltem Alemdar, Georgia Institute of Technology
Christopher Cappelli, Georgia Institute of Technology
ABSTRACT:
This NSF funded program is a five-year collaborative program aimed at addressing a shortage of quality physics and chemistry teachers. Additionally, the program is designed to improve science education by providing teacher leadership professional development models to science teachers to enable them to become a leader in their community. In this study, multiple evaluation frameworks are used to determine the overall program impact. One approach is a utilization-focused evaluation, developed by Patton (2008). It is described as, "evaluation done for and with specific intended primary users for specific, intended uses" (Patton, 2008, p. 37). Another approach utilized in this study is theory-driven evaluation (Chen, 1990). The conceptual framework for teacher leadership proposed by Snell and Swanson (2000) was used as the program theory to guide the evaluation and development of evaluation instruments. The purpose of this paper is to provide the summative results and impacts on program participants, including both Teacher Fellows (TFs) and Master Teacher Fellows (MTFs).

Exploring Teacher Perceptions of the Enhancing Understanding of Concepts and Practices of Science (EUCAPS) Project
Andy Cavagnetto, Washington State University
Judith Morrison, Washington State University
Kathryn Baldwin, Washington State University
Olusola Adesope, Washington State University
Nicole Ferry, Washington State University
ABSTRACT:
This paper reports results from a qualitative inquiry on data collected from a three-year professional development project occurring from 2013-2015. Thirty-three teachers from seven schools from two high needs geographically isolated districts in the Pacific Northwest region of the United States participated in the project. A thematic analysis was performed on several data artifacts including open-ended survey responses, participant reflections, journal entries, field notes, and blog posts. Three themes emerged from the preliminary analysis of the corpus of data. Teachers expressed a) concerns related to time for planning and collaboration, b) ideas related to control and student-centered classrooms, and c) comments focusing on standards and test scores as drivers of instruction. Breakdown by themes across grade-level groupings illustrate the strong context-dependent nature of teacher perceptions of the professional learning. Taken together our preliminary findings evoke some parallels with traditional ecosystems. In particular, the findings appear to suggest a strong relationship between environmental pressures and teachers' perceptions and actions.

Investigating Supports for In-Service Science Teachers' Knowledge Development in High Needs Schools
Stephen B. Witzig, University of Massachusetts, Dartmouth
ABSTRACT:
Reforms in science teaching and learning are at the forefront of science teacher educators' research and practice. However, amid the reform efforts, there is a problem retaining qualified teachers. Nationally, nearly 50% of new teachers leave the profession within 5 years. There is a need to support science teachers, particularly during their first few years. Research has indicated that highly structured induction and mentoring programs are effective in retaining teachers, especially those teaching in urban schools. This qualitative study was guided using case study methodology to address the following over-arching research question: In what ways did in-service science teachers' knowledge develop through participation in a multi-year professional development program? I posit the following three assertions: 1) In-service science teachers relied on content based experiences to help develop their science teacher knowledge; 2) In-service teachers found technology resources helpful, though found constraints of implementation that they discussed were outside of their control; and, 3) Teacher leadership took on many different forms in the various high-needs schools where these in-service teachers were employed. I discuss the implications of the findings as well as provide suggestions for future research in this area to continue the dialogue about our roles as science teacher educators.

Strand 8: In-service Science Teacher Education
Science Discourse
8:30am-10:00am, Hyatt Crockett CD
Presider: Noh Heejin, Korea National University of Education

Conversations around Practice: Mediating Opportunities to Learn About Teaching Science
Amy R. Ricketts, Pennsylvania State University
ABSTRACT:
This study analyzed the discourse of a group of middle school science teachers, a district science curriculum coordinator and a professor of science education who engaged in regular, job-embedded conversations around ambitious science teaching practices as a form of professional development. The study sought to explain: How do conversations around practice mediate educators' opportunities to learn about teaching? More specifically: 1) Which factors of this group's conversations around practice mediated their opportunities to learn? 2) How did the differential take up of these factors mediate the group's opportunities to learn? This microethnographic case study used discourse analysis of audio/video records of the group's talk along with video elicitation interviews in which the participants made sense of clips from the group meetings to answer those research questions. Analyses revealed five factors that consistently mediated the group's opportunity to learn through talking about practice: 1) the context of the conversation, 2) the tools participants used to represent their practices, 3) the stance with which participants represented their practice, 4) the resources participants drew on in the conversation, 5) the conversational routines in which the group engaged. These factors interacted in complex ways to afford and constrain various learning opportunities.

Practice-Based Professional Development on Science Discourse: Shifting Teacher Beliefs on Value and Barriers to Talk
Florencia Gomez Zaccarelli, Stanford University
Anita Tseng, Stanford University
Kirstin C. Busch, Stanford University
Jonathan Francis Osborne, Stanford
Hilda Borko, Stanford University
ABSTRACT:
Argumentation is a central practice in science that allows to explore real-world phenomena using evidence. In the classroom, this involves developing a science discourse where students share ideas supported by evidence and teachers facilitate reasoning. Teachers need support to be able to facilitate argumentation and science discourse. Practice-based PD can provide opportunities for teachers to grow needed skills, supporting the analysis of teaching practice in a community where participants can transform their beliefs about their practice. This study analyzes changes in teachers beliefs about value and barriers to science talk comparing perceptions before and after their participation in a practice-based PD program. Before the PD, participants valued talk as a way to reinforce student learning, develop their thinking, and verbalize ideas. After the PD, participants' perceptions of the value of talk included argumentation as a practice related to science discourse, and were more specific about the discursive purpose of arguing from evidence. Regarding barriers, before the PD, teachers mentioned student background knowledge, difficulties in managing student behavior and reduced importance of science in their schools. After the PD, teachers perceptions still included similar barriers, however they were more enabled to temper these barriers with specific actions to offset the challenges.

Teacher Facilitation of Elementary Science Discourse after a Professional Development Initiative: A Comparative Case Study
Emily Reigh, Stanford University
Florencia Gomez Zaccarelli, Stanford University
Hilda Borko, Stanford University
Jonathan Francis Osborne, Stanford University
ABSTRACT:
Despite the extensive knowledge base on effective teacher professional development (TPD), the field lacks an adequate understanding of how teachers implement knowledge from TPD experiences. This paper presents a case study of four teachers who participated in a TPD program focused on supporting classroom discourse and argumentation in elementary science. In order to understand changes in teacher practice, three years of classroom videos were analyzed for talk formats, activities, and moves that facilitate productive science discussions. All teachers adopted key practices from the TPD on the three parameters of analysis. However, their styles of implementation were markedly different. Two contrasting cases and the affordances of each will be presented. As teachers shifted to student-centered discussions, they struggled to negotiate their new role; the initial reaction for many was to step out of the discussion. Analysis of teacher moves shows their eventual adoption of a wide range of strategies that allowed them to actively facilitate the discussion without impeding student contributions. This paper offers strategies for engaging students in scientific argumentation, a major focus of the Next Generation Science Standards, and provides evidence of how teachers take up new practices, which will inform TPD developers and providers.

Strand 8: In-service Science Teacher Education
Chemistry & Physics Teaching
8:30am-10:00am, Hyatt Republic ABC
Presider: Peter S. Garik, Boston University

All Alone - A Study of Isolation of Chemistry Teachers in New York State
Linda Padwa, Stony Brook University
Keith Sheppard, Stony Brook University
ABSTRACT:
Prior research has focused on teacher isolation as a common yet undesirable characteristic of teaching. The isolation of teachers limits opportunities for professional engagement and hampers efforts at educational reform. Isolation is often cited as being prevalent in rural locations, though rarely is any quantitative data used to support such claims. This study investigates the isolation of chemistry teachers in New York State, i.e. teachers who are the only teachers of chemistry in their school. Using data from the New York State Education Department, isolated chemistry teachers were identified throughout the state in rural, urban and suburban locations, in for schools of different sizes and in schools with varying socio-economic backgrounds. Findings indicate that more than 20% of all NY chemistry teachers are isolated and while these teachers are commonly found in rural schools, they are also widely found in urban schools. Similarly, the isolated teachers are more prevalent in small and high needs schools. The data show that isolated chemistry teachers are often novice teachers and those who teach out-of- field. Recommendations are made for potential changes in teacher preparation and teaching assignments. Further study is called for to explore the impact of teacher isolation on chemistry instruction.

Impact of Professional Development on High School Physics Teaching and Student Learning
Dennis Sunal, University of Alabama
Cynthia Szymanski Sunal, University of Alabama
Marsha E. Simon, University of Alabama
Tara Ray, University of Alabama
Justina A. Ogodo, The University of Alabama, Tuscaloosa
Marilyn M. Stephens, University of Alabama
James W. Harrell, University of Alabama
Mohan Aggarwal, Alabama A&M University
Barbara Cady, Alabama A&M University
ABSTRACT:
Does in-service teacher physics focused professional development of teachers make a difference? The research investigated typical physics classrooms across a large intact state-wide population relating findings to teacher's experienced professional development. As part of a larger mixed method study, 34 classrooms were visited before and during the professional development program experiences. Results of the visits found the physics focused professional development fostered significant differences in the way physics teachers structured their classrooms, conducted teaching, and engaged students in learning. The findings were supported in each of the three parallel studies conducted using a convergent parallel research design. The results provided a unique picture of interrelated variables concurrently affecting physics teaching and implications for addressing in-service physics teachers' professional development needs.

Investigation of the Teacher's Perspective on Quantum Physics with the Delphi-method
Kim-Alessandro Weber, Leibniz Universitaet Hannover
Gunnar Friege, Leibniz Universitaet, Hannover
Rüdiger Scholz, Leibniz Universitaet, Hannover
ABSTRACT:
Due to the contemporary relevance in applications and in research and due to the paradigm value for a scientific literacy, quantum physics are a mandatory but difficult part of the curricula of the upper secondary school. Different approaches to undergraduate courses are discussed worldwide e.g. (Zollman, Rebello, & Hogg, 2002). On the other hand, there is a lack in empirical evidences for teacher's needs regarding a systematic training to support education in quantum physics at school. In order to gather more data about this issue we used the Delphi-Method with three rounds (1st Round N=84, 2nd Round N=54, 3rd Round N=70) with a group of experienced teachers. The data of these rounds is in nature quantitative and qualitative. Descriptive results as well as results from statistical analysis will be presented. The aim beyond this talk is to design a target group specific teacher's training course in collaboration of two institutes with their expertise in education and quantum optics. An outline of this course based on the empirical data will be given.

The Impact of a Professional Development Intervention on Knowledge for Teaching Chemical Bonding
Marissa S. Rollnick, Wits University
Vanessa Kind, Durham University
ABSTRACT:
Chemical bonding is a fundamental topic in any high school chemistry course, and requires rigorous teaching. This study investigates the impact of an intervention, namely a one day, interactive workshop aimed at addressing teachers' knowledge about aspects of chemical bonding and its teaching. The study was theoretically framed by the understanding that teachers transform their content knowledge (CK) using their knowledge of students to develop specialised knowledge for teaching the topic, referred to as pedagogical content knowledge (PCK). 21 teachers with varying experience and qualifications participated. Data collected included pre- and post-

responses to a diagnostic, multiple choice test pre- and immediately post- workshop, as well as a 3-month delayed post-test of Topic-specific PCK and CK. Pre- post-diagnostic test scores showed large improvement, with satisfactory scores in the delayed post-test. Findings reveal that the workshop had immediate impact on teachers' CK, and a moderately successful medium term impact. In terms of TSPCK, moderately good scores were recorded. Overall the study shows that a tightly focused workshop on a well-defined topic can have a medium term impact on teacher knowledge.

How Mentoring Applications Affect the Learning Environment: Reflections from Chemistry Teachers as Mentees ***(Virtual Presentation)***
Aysegul Saglam Arslan
Canan Cengiz
ABSTRACT:
The mentoring applications implemented to update teaching practices. The present study aims to assess the impact of mentorship practices on the professional practices of the mentees. Four chemistry teachers took part in the study as mentees and met their mentors once a week during the eight weeks. Each mentorship practice, brief seminars were given for the mentees. Thereafter mentees designed, in line with what they learned in the seminars, a learning environment (material, course plan preparation etc.) for application in the next class. Then they applied the course plans they developed, in actual class environments. The mentees were asked to fill out the self-assessment forms following the application. The content analysis of the self-assessment forms showed that the mentorship model applied in this study was found to have supported the professional development of the mentees. On the other hand, the teachers were found to lack sufficient skills for the development of solutions –in practice– for the problems they came across. One would consider explicit reflective thought trainings an effective means to enable the mentees take practical decisions much more easily.

Strand 11: Cultural, Social, and Gender Issues
Exploring Factors that Influence Access and Quality in STEM Education
8:30am-10:00am, HBG Convention Center 008B
Presider: Zoe E. Buck Bracey, BSCS

Enhancing Pre-service Science Teachers' Understanding on Entrepreneurship and Economics of Science
Sila Kaya, University of Limerick
Sibel Erduran, University of Oxford, UK
Naomi Birdthistle, Swinburne University of Technology
ABSTRACT:
Recently, social aspects of science in science education research started to gain attention, for instance; perspectives from the economics of science and entrepreneurship (e.g. Allchin, 2011). The purpose of this paper is to synthesize perspectives from the literature on economics of science, entrepreneurship, NOS and science education to have better understanding of how science works. The main objectives of this paper are to (a) scrutinize social aspects of science, namely economics of science and entrepreneurship, (b) transform the theoretical knowledge of social aspects of science into practical applications for science teaching and learning, (c) elaborate on the perspectives of pre-service science teachers on how science works, and inclusion of entrepreneurship and economics of science in science education, and (d) enhance pre-service science teachers' entrepreneurial skills in science education, such as critical thinking, creativity, teamwork and so on. Additionally, we propose a framework to illustrate the links between academia, markets and industry (AMI cycle for short). During one month, verbal and written data of the study has been collected from four participants in Turkey. As a result, the knowledge of participants on social aspects of how science works and entrepreneurial skills of participants improved throughout this study.

Examining Culturally and Linguistically Diverse Students' Learning Experiences When Co-constructing Scientific Models in a Middle School Science Classroom in Korea: Implications for Policy and Practice
Wanjoo Ahn, Seoul National University
Hee-Kyung Park, Seoul National University
Sonya N. Martin, Seoul National University
Ho-Jung Kim, Seoul National University
Hye-Eun Chu, Macquarie University
ABSTRACT:
The learning experiences of two culturally and linguistically diverse (CLD) students engaged in the co-construction of scientific models with three peers was examined to consider the ways that language and social interactions impacted on science learning for each student. Data included classroom observations and video/audio recordings from which interactions where language or social differences appeared to impact on students' science learning were identified and used to engage the participants in stimulated recall interviews to reflect on observed behaviors. Analysis revealed that while the CLD students experienced cognitive and affective difficulties during the modeling activities, their peers were able to support their learning by serving as an important resource for language and conceptual learning. CLD students also benefited the learning of their native Korean peers by promoting reflective

dialogue, contributing to the production of content knowledge, and offering innovative suggestions for developing their group's model. As Korean society becomes more diverse, it is increasingly important for teachers to be able to effectively facilitate CLD students' positive interactions with their peers and with science. Implications for professional development designed to educate science teachers about content-based instructional strategies that attend to social, cognitive, and linguistic needs of CLD students are discussed.

Glocalization: Exploring Local and Global Influences on Science Education Eesearch in Canada
Jerine Pegg, University of Alberta
Dawn Wiseman, McGill University
Michael Montgomery, University of Alberta
Angela Hostetler, University of Alberta
Sam Cheng, University of Alberta
ABSTRACT:
Since 2012 we have been engaged in an ongoing effort that considers the question: What makes Canadian science education research Canadian? To date, we have (1) developed a comprehensive database of researchers involved in science education research in Canada and their publications and (2) used this database as a means of examining how science education research is defined by relationships between people, ideas, and the contexts in which they work. The NARST 2017 conference theme, "Glocalization and Sustainability of Science Education Research and Practice" highlights the importance of taking both a global and local perspective in science education and science education research. But what does this actually look like and how do global and local influences impact academic disciplines such as science education? In this paper we draw on our previous studies to examine this question within the context of the Canadian science education research community. In the presentation, we will also discuss questions arising from our analyses and the possibilities of applying these analyses to other countries and contexts.

Long-term Impacts of Financial and Educational Support for Under-represented Minorities and First Generation STEM Undergraduates
Elizabeth Sciaky, University of California, Santa Barbara
Anne E. Leak, Rochester Institute of Technology
ABSTRACT:
Underrepresented minorities and first generation college students leave STEM fields at alarming rates (Ricco et al., 2010). Students likely to persist in engineering often report positive role models, a strong sense of community in engineering, and an intention to complete their engineering major (Eris et al., 2010; Litzler & Young, 2012). Yet, URM and first generation college students often struggle to see themselves in role models and as part of a community (Carlone et al., 2011). The impacts of efforts to support these students over time are poorly understood. We examined the influence of financial and educational supports using survey methods for 48 underrepresented or first generation students from 2011 to 2016. Quantitative and qualitative analysis was conducted on responses from students before, during and after the program. Financial stipends and a dedicated study space provided students with more time and opportunities to participate in a STEM community. Early tracking efforts show that these supports may help students complete their degrees and remain in STEM afterwards. Understanding strategies that support first generation and URMs has implications for improving access and equity in STEM fields.

Strand 11: Cultural, Social, and Gender Issues
Valuing Students' Cultural Experiences and Linguistic Practices
8:30am-10:00am, Hyatt Presidio ABC
Presider: Katherine Wade, Georgia State University

Critical Discourse Analysis of an Out-of-School Science Program for African American Girls
Katherine Wade, Georgia State University
Renee S. Schwartz, Georgia State University
ABSTRACT:
This paper explores the ways that informal science education can impact African American, middle school girls' scientific identity development by examining the interplay between school and out of school Discourses as well as how participants ascribed, resisted, and negotiated those Discourses. Data, including observations, focus groups, interviews, and artifacts, was collected over the course of one year in an after school science club and during one summer camp session. Findings included the impact of school sanctioned Discourses, particularly the "good girl" Discourse and "elite science" Discourse, despite explicit attempts by researchers to resist these Discourses in the OST science club. Although initially the club appealed to students who ascribed to both of these Discourses, engagement in scientific identities was shown to discredit the "elite science" Discourse over time, and allow for greater participation in science by students who did not ascribe to the "good girl" Discourse. After two semesters of participation in the science club, participants indicated that they viewed themselves as people who did science; however, more evidence is needed on how these growing identities are negotiated outside of the supportive setting of the science club.

Science Education in Multilingual Classrooms: The Case of a Middle Eastern Country
Sara Salloum, University of Balamand
Saouma B. Boujaoude, American University of Beirut
ABSTRACT:
A sociocultural perspective highlights significance of classroom discourse in shaping social lives of classrooms, with the teacher playing a central role as mediator of social and science language. In multilingual classrooms, use of native and global languages becomes especially important for supporting meaningful science learning. The purpose of this study was to examine: (a) multilingual language practices of participants that influence science understandings, and (b) how participants' give meanings to their language practices. Four qualitative case studies in middle school science classrooms with different SES were conducted. Data sources were classroom observations and video-recordings, teacher interviews, and student focus groups. We adapted Mortimer and Scott's (2003) framework for analyzing speech genres to discern language practices and participants' meaning-making. Classroom interactions were analyzed to examine communicative approach, discourse patterns, teacher intervention and science knowledge types (e.g., factual, conceptual, and procedural). Use and shifts between native and global language were analyzed. It was found that within lower SES contexts, teachers used native language for connecting phrases with the insertion of technical terms in English. Private schools teachers exhibited an almost "All English" approach which seemed to hinder deeper conceptual understandings. Results are discussed utilizing Bakhtin's notions of authoritarian and internally persuasive discourse.

Sociocultural and Critical Perspectives on Language and Discursive Homogenization in Bilingual Science Classrooms
Caitlin G. Fine, University of Colorado, Boulder
ABSTRACT:
Emergent bilinguals in science classrooms are often discursively homogenized as linguistically and cognitively deficient if they do not demonstrate native-speaker fluency in English or a readily adopt a traditional understanding of science. These reductive notions tend to create an opportunity gap that reinforces the oppressive effects of an educational system that values a linguistic capital characterized by White middle-class English, a bilingualism characterized by monolingual norms and scientific knowledge characterized by European understandings. As is explored in this conceptual paper, embracing a theory of holistic bilingualism and making room for translanguaging in the science classroom allows for an equitable definition of linguistic capital and gives voice to learners who have traditionally be silenced. Whether science learning takes the form of science talks, culturally responsive learning communities that embrace student funds of knowledge, or within an equity-oriented community of practice, all students should have access to learning about and participating in an array of science practices that reflect a variety of cultural, historical and linguistic ways of understanding and doing science.

The Formative Uses of Multimodal Representations in Linguistically Diverse Science Classrooms: Potential and Challenges
Preetha K. Menon, University of California, Santa Cruz
ABSTRACT:
Today's schools face unprecedented challenges in preparing ELLs as they lack instructional supports and fair and valid assessments to support academic learning in classroom settings. This study invokes the theory of multimodality and assessment within a sociocultural perspective. The main research question guiding this study: How do multimodal tasks support science learning in linguistically diverse classrooms? This question leads to examining the students' perspectives on the use of multimodal tasks and using a science and language learning rubric to examine student learning in the classrooms. Results show the scaffolding strategies like analogies and re-representation of ideas through different modes. Rubric scoring indicated ELLs had the highest gains in the scores in the visual diagrams, redesignated students had the highest scores in the comic strip and those designated as above proficient in language arts and science had the highest scores in final visual diagram. ELL status and proficiencies in language arts and science influenced the integration of science and language learning. With the advent of NGSS, the findings illustrate the formative potential of the multimodal tasks to integrate the understanding of science content and language and assessing students' learning over time.

Strand 12: Educational Technology
Related Paper Set: Studying Science and Engineering Learning using Design and Simulation Technologies
8:30am-10:00am, Hyatt Seguin AB
Presider: Senay Purzer, Purdue University
Discussants:
Alejandra Magana, Purdue University
Jennifer Chiu, University of Virginia
Joyce Massicotte, Concord Consortium
Mitchell Zielinski, Purdue University
ABSTRACT:
This related paper set explores the process of learning science and engineering concepts and practices using design and simulation technologies. Design software and computer simulations can only help promote student learning but are also excellent data collection

and research tools that can gather information on students' performance at the very micro behavior levels. The first paper examines student learning of thermodynamics concepts using a computer-based engineering design environment. The second paper focuses on the teachers and ways they maximize student learning in engineering design using a computer-aided design tool. The third paper compares two different approaches to design project contexts in relationship to student learning gains. The forth paper examines the educational and practical values in technology-enabled design projects and the need for design beyond school learning. All together, the papers in this set present results from students learning and teacher practices.

Using Visualizations to Support Understanding and Application of Thermodynamics Concepts in Middle School Engineering Design Projects
Amanda Gonczi , University of Virginia
Jennifer L. Chiu , University of Virginia

Scaffolding Teachers for Maximizing Student Learning of Engineering Design Practices in Formal Classrooms
Chandan Dasgupta, Purdue University
Alejandra Magana , Purdue University

Comparing Depth of Design Context in the 7th Grade Classroom Subject/Proble
Molly Goldstein, Purdue University
Senay Purzer, Purdue University
Mitchell W. Zielinski , Purdue University

Empowering Students to Be Change Makers with Innovative Design Tools
Jie Chao, The Concord Consortium
Charles Xie, Concord Consortium
Corey Schimpf, Concord Consortium
Joyce Massicotte, Concord Consortium
Saeid Nourian, Concord Consortium

Strand 14: Environmental Education
Socio-scientific Issues, Sense of Place
8:30am-10:00am, Hyatt Travis CD
Presider: Xavier Fazio, Brock University

A Case Study of a Science and a Social Studies Teachers' Experiences of Co-teaching SSI-based Environmental Ethics Class
Engin Karahan, Eskisehir Osmangazi University
Gillian Roehrig, University of Minnesota
ABSTRACT:
This case study demonstrated the ways a science and a social studies teachers co-designed and co-taught an Environmental Ethics class based on their pedagogical and content-related strengths and expertise. The findings indicated that participant teachers strong believed that traditional environmental science curriculum and textbooks were not fully able to address socioscientific issues; therefore, they structured their SSI- based class on a framework called triple bottom line (social, economic, and environmental), as well as using external resources and dedicating a significant part of their curriculum to multidisciplinary content. In addition to the co-teaching aspect of Environmental Ethics class, the results of this study also demonstrated the strategies these teachers used to promote the agency of their students in their classroom.

Developing Empathy through Place-based Environmental Socioscientific Issues
Benjamin C. Herman, University of Missouri-Columbia
Dana L. Zeidler, University of South Florida
Mark H. Newton, University of South Florida
ABSTRACT:
Those engaging contentious environmental issues (CEI) such as species introduction and climate change must navigate the diverse interests of many anthropocentric and ecocentric positions. This requires developing and utilizing a sense of empathy that guides CEI decision-making congruent with environmental and sociocultural stewardship. This mixed-methods investigation examined how twenty-four undergraduates, experiencing socioscientific issues instruction embedded within a place-based CEI course in the Greater Yellowstone Area manifested empathy toward entities impacted by CEI. While forms of empathetic distress are strong emotive responses that facilitate pro-social behaviors, apathy, general caring and conditional empathy are weaker emotive responses that impede pro-social behaviors. The students displayed four types of general affective responses that were ecocentric and anthropocentric in nature consisting of: 1) apathy, 2) general caring, 3) conditional empathy and 4) empathetic distress. Deeper analyses revealed three

ways the students manifested restricted conditional empathy: 1) judgment of the sufferer, 2) inexperience/helplessness, and 3) dispersion of responsibility; and four ways the students expressed unrestricted empathetic distress: 1) sympathetic distress, 2) empathetic anger, 3) feelings of injustice, and 4) empathetic guilt. Through completing the place-based CEI focused course, the students' empathy significantly shifted from forms that impede, to those that facilitate pro-social behaviors.

Sense of Conservation: When Is a Black Rat Snake (Elaphe obsolete) Really Just a Snake?
Jennifer Idema, NOAA
Patricia Patrick, Consultant
ABSTRACT:
I describe a research project in which middle level students (ages 11-14) knowledge of local plants and animals was assessed. The findings indicated that students were aware of local flora and fauna, but used common names. For example, when asked to identify a black rat snake students identified the organism as black snake or snake. In the discussion, I argue that this is the starting point at which conservation educators must start in their program design. Educators must take into account the conservation related knowledge of the community in which they work. People form emotional bonds and familiarity with local places. Those local places include the ecosystems and organisms of the area. The bonds and familiarity that form between people and their local environments do not form because people know the scientific name of an organism. The bonds form with the local natural community because people have a sense of where they live. From this basic idea, I describe the characteristics of Sense of Conservation and correlate them with the notion that people have emotional bonds and strongly felt beliefs about local nature that influence the value they place on conservation.

Using Students´ Sense of Place as a way to Teach Environmental Issues from Local-global
S.Lizette Ramos, University of Guadalajara
Karina De Alba, Instituto Superior de Investigación y Docencia para el Magisterio
ABSTRACT:
The purpose of this studio was to use a sense of place to gain insights into 35 second grade students beliefs as related to the environment, the house where they live and their school. The concept of a sense of place, and place were the theoretical frameworks used for this study. Methodologically, participating second grade students were asked to draw three pictures: the environment, their favorite places in their homes and their favorite places in school. Based on their individual drawings three separate individual interviews of all 35 students were conducted. All artifacts were analyzed using ATLAS.ti software. The results indicate that a sense of place is linked to the local as opposed to a global context. Students have developed a sense of place that is connected to where they live, which includes places such as a favorite room. Participating students were able explain environmental degradation by indicating that there is a lack of compliance of rules and /or a lack of penalties associated with environmental care. The family appears as an important promoter of environmental care. Finally, the gender of students as an indicator of sense of place were different in boys and girls.

Concurrent Session #11
10:15am – 11:45am

External Policy and Relations Committee, Publications Advisory Committee, and Strand 15: Policy Co-Sponsored Session
Admin Symposium: Make a Difference: Practical Tools and Strategies for Reaching Policy Audiences
10:15am-11:45am, Hyatt Travis CD
Presider: Katherine L. McNeill, Boston College
Presenters:
Philip L. Bell, University of Washington
Sinead Chalmers, Rennie Center
Kenneth W. Heydrick, Texas
Peter McLaren, Next Gen Education
Jodi Peterson, National Science Teachers Association
ABSTRACT:
As NARST members, our work is often communicated only to other researchers. However, as we seek to impact science education policy and practice, it is crucial that we reach out to those who craft policies at the local, state, and national levels. This panel discussion will feature 1) researchers who have successfully shared their work with policy makers, 2) liaisons between researchers and policy makers, and 3) policy makers who engage with research. The panel will focus on practical tools, strategies, and perspectives for communicating research findings with policy audiences. Panelists will address how to summarize and display research for a policy audience, how to disseminate research to policy audiences, where policy makers find research, and what formats policy makers find most accessible and readable. Specific strategies (e.g., policy briefs, blogs, twitter) will be provided as exemplars.

Strand 1: Science Learning, Understanding and Conceptual Change
Students Argumentation about Science and Scientific Evidence
10:15am-11:45am, HBG Convention Center 006D
Presider: Matthew J. Benus, Indiana University Northwest

Examining the Concept of Evidence in Science Education
Jamison M. Wills, Purdue University
ABSTRACT:
Educational researchers in science have generated considerable scholarship on students' knowledge of scientific evidence. However, many of these studies incorporate straightforward and under-analyzed notions of evidence. In these contexts, evidence is presented in simple forms and is disconnected from other phases of scientific activity. According to contemporary thinking in the philosophy and history of science, evidence in science is multifaceted, sophisticated, and involves the simultaneous coordination of disciplinary knowledge and methodological practices. I argue that revising notions of scientific evidence to be more representative of science has the potential to improve science learning. I present a framework of evidential themes based on a conceptual analysis of evidence in the philosophical literature. The theoretical framework includes three main categories: (a) validity & reliability (design & collection focused themes); (b) quality/sufficiency of evidential analysis & interpretation; and (c) social factors of evidence in science.

Disagreement Discourse Processes and Strategies in the Middle School Science Inquiry Classroom
Randi M. Zimmerman, Rutgers Graduate School of Education
Clark A. Chinn, Rutgers University
Ravit Golan Duncan, Rutgers University
ABSTRACT:
Researchers promote and study argumentation in the science classroom so that students learn to engage in real science practices. Yet, there is relatively little research that presents a systematic portrait of what happens within such interventions. Disagreement is typically at the heart of productive argumentation in science. How disagreements are addressed will impact the efficacy of argumentation in the classroom. We examine a relatively large sample of disagreements to better understand the different ways in which they emerge and progress. By focusing on episodes of disagreement within classrooms engaging in science inquiry we have identified locations of productive discourse and been able to locate discourse that is derailed before it could develop. Students made explicit their reasoning about whether they thought processes were reliable and also elaborated on their criteria by which to evaluate such reliable processes. Disagreements usually ended when the teacher changed the topic prior to resolution. This suggests that a potent means to improving argumentation around disagreement would be to encourage teachers to hold off on changing the topic and instead allow disagreements to unfold further. Understanding these relationships between sustained and productive disagreements can guide the development of promising instructional recommendations for teachers and for designers.

Choosing Among Competing Models: Students' Evidence-based Arguments
Hebbah El-Moslimany, Rutgers University
Na'ama Y. Av-Shalom, Rutgers University
Ravit Golan Duncan, Rutgers University
Clark A. Chinn, Rutgers University
ABSTRACT:
Modeling is an integral part of scientific practice. In this paper, we discuss the results of a written assessment task with seventh-grade students that occurred pre and post the implementation of a life science model based inquiry curriculum. The curriculum spanned the course of several months and included creating and using criteria lists for model evaluation, and using a variety of evidence. The assessment task asked students to choose between two comparable, competing models and write an argument in support of their chosen model. We situated our analyses within Krajcik and McNeill's (2015) claims, evidence, reasoning, and rebuttal (CERR) framework to determine the ways in which students' arguments improved with instruction and whether there were differences in the arguments of students choosing the correct or incorrect model. From pre to post, we found that although students did not improve in choosing the correct model, other aspects of their argumentation skills (e.g., evidence usage) improved when they selected the correct model. Students' ability to reason, in terms of justifying evidence-model links, increased for all students in the post assessment task.

Argumentative Levels of Students' Written Statements on the Validity of an Electron Cloud Model
Sulaiman M. Al-Balushi, Sultan Qaboos University
ABSTRACT:
The current study analyzed students' written statements to defend their stands with respect to the validity of the electron cloud as a model that represents the atom. The sample was 57 grade-ten, female students in Oman. The participants were presented with a sketch of the electron cloud. They were asked to state whether they thought that this model represents the atom. Then they were asked to defend their positions in writing. Based on the literatures on students' argumentation, a five-level analysis system was developed for the purpose of the current study to determine the level of argumentation. Participants' written statements were then analyzed for their

level of argumentation. The reliability coefficient of the coding process was 0.77. The findings show that participants' argumentative levels were expressed as follows: level 0 (0.88%), level I (37.87%), level II (24.67%), level III (16.30%), and level IV (20.26%). At level IV students were expected to focus on the electron cloud as submicroscopic entity and to support their position with supporting information such as a personal experience, example, experiment, equipment, prediction, metaphore, principle, cause-effect relationship or function. On the other hand, at level 0 students did not attempt to defend or justify their position.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Equity Issues
10:15am-11:45am, HBG Convention Center 007A
Presider: Michael Giamellaro, Oregon State University

Exploring the Teaching and Learning of Health Outcomes: Intersections of Race, Place, and Socioeconomic Status
Tammie Visintainer, TERC
ABSTRACT:
This study explores how a biology instructor from a summer science program serving racially underrepresented youth engaged students in a unit examining health disparities and inequities at the intersections of race, place, and socioeconomic status. Using instructor and student interviews, and program observations, this study examines how an instructor's pedagogical vision and goal to help students think critically about health disparities and outcomes shaped the resources she made available. In addition, this study explores how students, who all self-identified as racial minorities, made sense of health disparities following instruction. Findings illustrate connections between an instructor's vision and program resources, such as graphs of national health statistics by income and race, that fostered student sense making and critical thinking skills, while integrating complex issues across local and broad structural contexts. Students' demonstrated rich and complex sense making. Their experiences illustrate the challenges and tensions associated with reasoning about socio-scientific issues, balancing personal and local experiences with broad social and institutional structures and inequities, and maintaining hope and possibility. Findings can be used to create expansive learning environments that engage students in the complexities of pressing socio-scientific issues.

Gendered Interest: High School Genetics Curricula Activate Topical Interest in Biology amongst Girls
Daniel C. Edelson, BSCS
Brian M. Donovan, BSCS
Molly Stuhlsatz, BSCS
ABSTRACT:
Studies have found that a greater proportion of women pursue advanced degrees in biology than the physical sciences. We explore whether this gendered phenomenon can be explained, in part, by the nature of science instruction during a critical developmental phase. In this exploratory study of a pre-existing data set, we applied computer assisted quantitative content analysis to open ended responses to an intrinsic motivation prompt in a sample of 3942 students in middle school (748), high school (2859), and college level (748) biology courses in five US states. We find that interest in human biology peaks at the high school level. We explore this cross-sectional difference using data from a matched-quasi experiment within this dataset in which 1,337 high schoolers studied genetics either through non-human examples or a combination of human and non-human examples. We find that learning genetics with non-human examples has a significant effect on stated interest in human biology – an effect that is implicated in motivations to study science. Furthermore, this effect is significantly greater in girls than boys. Interest in human-biology appears to be a motivational factor that is activated in girls when human examples are included in genetics instruction.

Urban Elementary Students' Conceptions of Engineering after Receiving an Integrated STEM Curriculum
David E. McKinney, The Johns Hopkins University
Catherine Kruchten, The Johns Hopkins University
Nicholas W. Lehn, The Johns Hopkins University
Carolyn A. Parker, The John Hopkins University
Sandra Strittmatter, The Johns Hopkins University
ABSTRACT:
This paper describes the conceptions elementary students have of engineers and engineering. The research is part of SABES, an NSF-funded Math-Science Partnership between Johns Hopkins University and Baltimore City Public Schools to improve STEM education and motivation in nine elementary schools through the implementation of a STEM curriculum, among other interventions. The sample in this study is comprised of students in the nine intervention schools and students in four comparison schools where students receive a more traditional, "business-as-usual" science curriculum. Students were surveyed and responded to an open-ended question asking their thoughts on the words "engineer" and "engineering." Student responses were coded with a coding schema based on prior research in the field; for responses that did not fit in the provisional schema, an inductive process was used to allow themes to emerge. Results indicated that the most common student conceptions of engineers are those of laborer, mechanic, and technician, which aligns with prior research. Some students' conceptions aligned with a designer. The conception of general scientist also emerged. The

responses that aligned with designer and scientist, and those that expressed aspirations to be an engineer were predominately observed in students from the intervention schools.

Using Contextual Mitigating Factors Analysis to Interrogate STEM Intervention Efforts
Alejandro J. Gallard, Georgia Southern University
Wesley Pitts, CUNY
S. Lizette Ramos-de Robles, Universidad de Guadalajara
Katie Brkich, Georgia Southern University
Belinda Flores Bustos, University of Texas, San Antonio
Lorena Claeys, University of Texas, San Antonio
ABSTRACT:
The purpose of the study is to understand the underrepresentation of Latinas in STEM fields. Our study was guided by the following research question: How do Latinas read the context in the process of shaping networks of social places in order to sustain success along the continuum of achievement in STEM pipelines? To address the research question, we used a case study approach and narrowed our observations to Latinas who are successful in STEM pipelines. We explore the stories of individuals as they recall their lived experiences in multiple social places along a complex trajectory in pursuing a STEM career. Using contextual mitigating factors (CMFs) as an analytic tool, we considered factors that exists in spaces across contexts and used them to examine the case study data. We make the case for using CMFs to unearth the presence and uptake of cultural enactment that includes resiliency as well as other unique sociocultural factors which contribute to success from both individual and collective bases.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Related Paper Set: Teachers' PCK for Structure and Properties of Matter: Methodological and Practical Considerations
10:15am-11:45am, HBG Convention Center 006A
Discussant: Patricia Friedrichsen, University of Missouri
ABSTRACT:
Concepts about the structure and properties of matter, and specifically the 'small particle model' (SPM) are important across the science disciplines and central to science curricula worldwide, providing a foundation for learning other fundamental concepts. In regard to teaching SPM, however, the literature is almost entirely focused on aspects of student thinking. We know very little about other kinds of knowledge that is necessary for teachers to be able to teach SPM effectively--such as instructional approaches, assessment strategies, understanding of models and modelling, etc. Specifically, we lack an understanding of the pedagogical content knowledge (PCK) necessary for teaching SPM. In this paper set, we explore the effectiveness of different methodological approaches in eliciting, characterizing, and capturing the development of teachers' PCK for SPM. Given the paucity of studies, we use examples of studies of both elementary and secondary teachers to consider what these reveal about the particular needs of teachers in approaching the teaching of SPM in the primary grades, and how standards differentiate learning about SPM. We also discuss critically our results and test instruments and suggest implications both for research and teachers' professional development.

Eliciting Elementary Teachers' PCK for the Small Particle Model
Patrick S. Smith, Horizon Research, Inc.
Patricia J. Friedrichsen, University of Missouri, Columbia

Characterizing Elementary Teachers' Initial PCK for Teaching Structure and Properties of Matter
Deborah L. Hanuscin, University of Missouri, Columbia
Dante Cisterna, University of Missouri
Kelsey Lipsitz, University of Missouri

Capturing the Development of PCK of Pre-service Teachers of Chemistry on Particle Models
Jan H. Van Driel, Leiden University

Teachers' PCK in the Context of Teaching a Unit on Atomic Structure of Matter
Martina Struebe, University of Duisburg, Essen
Oliver Tepner, University of Regensburg, Germany
Elke Sumfleth, University of Duisburg, Essen

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Increasing Learning Opportunities in Curriculum, Assessments and Instruction
10:15am-11:45am, HBG Convention Center 007B
Presider: Marissa S. Rollnick, Wits University

Critical Analysis of the Advanced Placement Environmental Science Exam and Its Implications for Practice
Kelly F. Flanagan, Columbia University
ABSTRACT:
Advanced Placement (AP) science courses are found in classrooms across the country. Research shows that students who pass AP exams are more likely to succeed in college science courses and pursue a career in science. While participation has grown, the success rate remains relatively low, especially for AP Environmental Science (APES). A critical question for educators is: what can we learn from student responses to improve instruction, learning, and success in this discipline, for all students? This study analyzed item-level responses from the 2008 APES exam – coded to NGSS and Bloom's Taxonomy. A cluster analysis was performed on passing and failing scores of a 2 and a 3 and the results were mapped to demographic data. Results identified distinct response patterns. While students achieved the same score, they did so by excelling in different questions representing various reasoning and skill levels. Furthermore, there were significant differences by gender across question types and attributes. The methods in the study identified domains where students need support, which can be used by many stakeholders, especially classroom teachers, to improve success rates on this, and similar exams. These findings can help teachers develop effective instructional practices and strategies to raise student performance.

Identifying the Cognitive and Metacognitive Strategies Used by 9th Grade Students Answering the Multiple-Choice Science Questions
Emine H. Diken, Kafkas University
Nejla Yuruk, Gazi University
ABSTRACT:
The present study aims at identifying the cognitive and metacognitive strategies used by 9th grade students at Science High Schools, Anatolian High Schools and Vocational High Schools who answered the multiple-choice science questions correctly other than those answering wrongly. Five students from each high school participated in the study. Case study out of qualitative research designs was used in the current research. The students thought aloud while answering the questions and semi-structured interviews were conducted with them after solving each Science question. The findings of the study revealed that the students who answered multiple-choice science questions correctly used cognitive and metacognitive strategies in a greater number and variety than those answering the same questions wrongly. It was also found out that although they have applied cognitive strategies more in number and variety while answering science multiple-choice questions, some students from Science High Schools and Anatolian High Schools who answered the questions wrongly had misconceptions.

Intended Design Versus Teacher Enactment of a DBR Project-based Middle School Biology Curriculum
Janice L. Anderson , University of North Carolina, Chapel Hill
Lana Minshew, University of North Carolina, Chapel Hill
Kelly Barber-Lester, University of North Carolina, Chapel Hill
Sharon Derry, University of North Carolina, Chapel Hill
ABSTRACT:
Recent focus of educational policy makers on STEM education has created a priority for promoting STEM education for our next generation of scientist and engineers in our schools, while ensuring diversity and global competitiveness of the new STEM workforce. In order for these current reform efforts to be successful, teachers need adequate content knowledge and reform curricular materials. These reform curriculum materials play an important role in helping teachers to engage their students in complex scientific thinking. However, how these reform curricula are enacted does not look the same across classrooms due to the influences of teachers' understanding of the content, beliefs about what is important, and their ideas about the roles of teachers and students in the classroom. In this study we examine a high needs rural middle school teacher's enactment of a designed, project based curriculum.

Science Tasks, Teachers' Thinking about Task Demands and Students' Opportunities to Learn
Miray Tekkumru-Kisa, Florida State University
Hannah Hiester, Florida State University
Zahid Kisa, Florida State University
ABSTRACT:
The Framework for K–12 Science Education and the Next Generation Science Standards introduce a new vision for teaching and learning science. Teachers' selection of instructional tasks that can position students to engage in science as emphasized in the NGSS will be critical to achieving this vision. This study aims to investigate (i) the kinds of tasks assigned to students in science classrooms, and (ii) teachers' reasons for what makes tasks cognitively demanding or not. Based on our analysis 224 science tasks shared by science teachers through a statewide survey, many of the tasks, which were identified by teachers as demanding high cognitive effort from students, demand low cognitive effort. Majority of the low-level tasks require students to reproduce information (e.g. definitions, formulas) related to scientific ideas. These are important because students' opportunities to learn are shaped by the tasks that they are assigned. The qualitative analyses of teachers' responses to survey questions have begun to reveal how and why teachers characterize science tasks as demanding high or low cognitive effort. This study provides implications for the kinds of support teachers need to identify cognitively demanding tasks aligned with the NGSS vision.

Examination of the Relationship between Students' Metacognition and Their Problem Solving Skills in Physics
Zeynep Dulger, Marmara University
Feral Ogan-Bekiroglu, Marmara University
ABSTRACT:
The purposes of this study were to investigate a significant relationship between metacognition and problem solving and to examine students' metacognitive behaviors while they were solving physics problems. A correlational research design was carried out for this research. Both qualitative and quantitative methods were used to collect and analyze the data. Participants in the study were eleventh graders studying in an urban all-boys school. The Metacognition Awareness Inventory was used in this study to determine the participants' metacognition. In order to identify the participants' problem solving skills, Physics Problem Solving Assessment inventory was prepared. A taxonomy of cognitive-metacognitive problem solving behaviors was used to code the students' verbalizations of their thinking and to examine how the students used their metacognition when they worked on the physics problems. Pearson correlation coefficient analyses showed a significant medium level positive relationship between the students' metacognitive awareness and their problem solving skills. Moreover, the students having different metacognitive awareness performed diverse metacognitive process from each other while they were working on physics problems. Since improving students' problem solving skills continues to be a major goal of science education, these conclusions suggest that instruction based on metacognition can promote increased problem solving in the classroom.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Emotional and Motivational Aspects of Science Teaching and Learning
10:15am-11:45am, Hyatt Presidio ABC
Presider: Juan Jimenez, Illinois Institute of Technology

Connections between Emotions and Teacher Practice: Implementing an Unconventional Pedagogy on Climate Change
Sarah El Halwany, University of Toronto, OISE
Minja Milanovic
Mirjan Krstovic
Majd Zouda, University of Toronto
John Lawrence Bencze, University of Toronto
ABSTRACT:
Research on science teaching has often focused on the cognitive side of teachers' work, overlooking how teaching is also an "emotional practice" (Hargreaves, 2005). In this study, we explore emotional experiences of three secondary science teachers as they implement an unconventional pedagogy related to climate change. We draw on the construct of "emotional ecology" (Zembylas, 2007) to explore extent to which teachers' practice is entangled with emotional experiences at individual, relational and socio-political planes. One emerging finding points to possible "tensions" between how teachers discussed aspects of the pedagogy in affective terms while de-emphasizing role of emotions in their practice. A general portrayal of science as emotionally detached enterprise (Hodson, 2008) is perhaps mirrored in teachers' tendency to view their practice as a rational activity. On the other hand, this study highlighted the caring nature of teachers' work and how care unfolded as each teacher subjectively negotiated personal, relational and socio-political demands of the tasks at hand. Some implications include allowing teachers to reflect on emotional aspects of teaching and learning to render visible "emotional sense-making" (Hufnagel, 2015) on socio-scientific issues, as well as hegemonic discourses in the teaching profession that get enacted through emotions (Chubbuck & Zembylas, 2008).

How Individual Resources Relate to Small Group Functioning in Biology Engineering Design Tasks
Elizabeth McEneaney, University of Massachusetts, Amherst
Miancheng Guo, University of Massachusetts, Amherst
Martina Nieswandt, University of Massachusetts, Amherst
ABSTRACT:
This study investigates the relationship between individual student resources (cognitive, social and affective resources) and reported group functioning over the course of three engineering design tasks. Building on Barron's (2003) notion that academically effective groups must construct a "dual problem solving space" (cognitive and social/relational) to incorporate Linnenbrink-Garcia, et al.'s (2011) emphasis on the critical role of affect in group work, we theorize that well-functioning groups must develop a "triple problem solving space" (Authors 2015) with positively-valenced affective, social, and cognitive dimensions. Specifically, we hypothesize that 1) individuals who bring strong resources to the group are more likely to report better subsequent group functioning along these dimensions and 2) individuals belonging to groups where other group members bring strong resources to the group are more likely to report better group functioning. In preliminary analysis, the impact of social and affective resources on group functioning is highlighted.

Investigating Factors Underlying Secondary Teachers' Motivation to Use Problem-based Learning

Huei Chen Lao, National Institute of Environmental Health Sciences
Margaret R. Blanchard, North Carolina State University

ABSTRACT:
For this study, a survey was developed and administered to middle and high school teachers (n = 156) to examine factors that motivated teachers' use of problem-based learning (PBL). Based on the expectancy-value theory of achievement motivation (EVT) and self-determination theory (SDT), this instrument measured respondents' perceived competence, autonomy and relatedness, and the value and costs they placed on implementing PBL. Results indicated that although teachers without PBL experience (the non-PBL group) and teachers with PBL experience (the PBL group) shared some general conceptions about PBL, the PBL group had significantly more formal training for this pedagogy. Teachers in the PBL group had higher levels of perceived competence, value of this pedagogy to students and teachers, and support from peers. The PBL group teachers also placed lower level of cost in implementing PBL than the non-PBL group teachers did. These results indicated that teachers' desire to implement PBL was affected by multiple factors and they were motivated to adopt PBL when they believed that the overall values outweighed the costs associated with this pedagogy.

Teaching Topics in Ecology Through Incongruity
Francine Wizner, Albany University
ABSTRACT:
This is an examination of the manner in which an educator teaches ecology through humorous comparisons. Content humor is a useful strategy in drawing the attention of students and improving their receptivity toward scientific information. Previous studies have found that humor has an overall positive effect on learning. This study employed multiple data sources to determine how a secondary biology teacher compared disparate concepts to ecology topics, how parity between the concepts was demonstrated to students, whether students recognized the comparisons being made, and students' perceptions of how the comparisons affected their learning of ecology. The teacher made numerous comparisons, among which were those related to global climate change and ecology. Students recognized the comparisons made and were able to correctly answer content questions related to them. Helping students become critical thinkers is a trademark of science teachers. Science teachers who take the risk of adopting some comedic attributes may earn the reward of imparting behaviors on their students such as critical thinking skills, the ability to explore questions in a detached manner, and the ability to search for new perspectives. The results of this research may encourage additional study on how secondary science teachers use humor to explain scientific concepts and may also encourage science teachers to investigate novel ways that instructional humor can be used in their classrooms.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Engineering and STEM Cognition
10:15am-11:45am, HBG Convention Center 007C
Presider: Carina M. Rebello, Purdue University

Developing an Analytical Framework to Characterize Student Reasoning of Interdisciplinary Phenomena
Emily Scott, Michigan State University
Vashti Sawtelle, Michigan State University
Charles W. Anderson, Michigan State University
Mashood K. Kandiyil, Michigan State University
Rebecca L. Matz, Michigan State University
Sonia M. Underwood, Florida International University
ABSTRACT:
Many of today's pressing societal problems require interdisciplinary solutions across scientific fields, yet it is unclear if students are being adequately prepared to tackle these problems given the discipline-centric focus of many university science programs. We use everyday phenomena that contain elements from physics, chemistry, and biology to evaluate how undergraduate science majors explain interdisciplinary phenomena. From these accounts, we generated a framework that characterizes the broad range of ideas students' use when reasoning about these phenomena. Our framework includes four dimensions: i) Structural scale of reasoning - the scale of materials students primarily use in their explanations; ii) Causal reasoning - the kinds of models students use (e.g., force-dynamic to structure-function); iii) Explanatory frame - the kinds of language and principles/concepts students use; and iv) Characterization of phenomena - the relatedness of analogies that students draw on to the processes they describe. This work provides an important first step towards understanding the ways students' reason about interdisciplinary problems that can aid in developing instructional methods that foster interdisciplinary reasoning in undergraduate science majors.

Exploring the Reflection and Feedback Cycle to Enhance Engineering Students' Learning
Muhsin Menekse, Purdue University
Xiangmin Fan, University of Pittsburgh
Wencan Luo, University of Pittsburgh

Jingtao Wang, University of Pittsburgh
Diane Litman, University of Pittsburgh
ABSTRACT:
This study primarily explored the effectiveness of the reflection and feedback (RF) cycle on students' learning outcomes by integrating Natural Language Processing (NLP) with a mobile application called CourseMIRROR, which was developed to prompt students to reflect on confusing concepts. CourseMIRROR uses an NLP algorithm to generate relevant summaries of reflections for each lecture by clustering them based on common themes. Available to both instructors and students, these summaries allow users to understand the difficulties that their students encountered from the lecture. Instructors use these summaries to provide feedback at the following lecture, and eventually these continuous reflections help them identify students' misunderstandings and tailor their lessons to meet students' needs. Results from an implementation in an industrial engineering class showed the students in the intervention condition (N1 = 74) performed significantly better on the second and final exams compared to students in the control condition (N2 = 79).

First-Year Engineering Students' Implicit Theories of Creativity in Design
Jaclyn K. Murray, Georgia Institute of Technology
Barbara A. Crawford, University of Georgia
ABSTRACT:
A variety of views exist about STEM communities of practice. Views arise from experience and may not be consistent with actual practice. Implicit theories and explicit theories describe individuals' constructions of phenomenon and evidence-based theories, respectively. The present study investigates implicit theories of creativity in engineering design. How doe students' views align with explicit theories of engineering creativity? The goal is to understand implicit theories and the role they play in a domain-specific design task. Implicit theories of creativity in engineering informs the processes and products students use and create, respectively, in design. An understanding of student views enables instructors to craft lessons that either assimilate or accommodate domain-specific design knowledge. Knowing students' views is the first step in transforming views toward alignment with domain-specific design practices consistent with engineering communities of practice.

Strand 6: Science Learning in Informal Contexts
Symposium: Science Communication Education for STEM Professionals: Teaching Scientists to Communicate with Non-Expert Audiences
10:15am-11:45am, Hyatt Crockett CD
Presider: Martin Storksdieck, Oregon State University
Presenters:
Ayelet Baram-Tsabari, Technion-Israel Institute of Technology
Bruce V. Lewenstein, Cornell University
Anthony Dudo, The University of Texas, Austin
Tiffany Lohwater, Center for Public Engagement with Science & Technology, AAAS
Martin Storksdieck, Oregon State University
ABSTRACT:
The field of science communication is growing rapidly, both in practice and in scholarly attention. One area of particular interest is the growing number of training programs in science communication for scientists. This symposium will discuss international research and practice of science communication education for STEM professionals. It will focus on the following questions: (1) Which theoretical framework should guide the study and practice of science communication education?; (2) How do scientists and science communication trainers view the goals of science communication in general, and prioritize the goals of science communication training in particular?; (3) What do we know about effective pedagogy and best practices for science communication education?, and (4) How could science communication education be assessed at the course and learner level? We argue that identifying conceptually-based learning goals and effective pedagogy, will allow shared practices of assessments for individual learning and evaluations of training programs to emerge. This process will contribute to science communication education to STEM professionals, and by doing so will affect the availability of quality science messages in the traditional and new media and increase opportunities for science engagement of students, teachers and general public with science.

Strand 7: Pre-service Science Teacher Education
Nature of Science and Preservice Teachers
10:15am-11:45am, HBG Convention Center 007D
Presider: Rebekka Darner Gougis, Illinois State University

Contextualization of Nature of Science Within the Socioscientific Issues Framework
Dilek Karisan, Adnan Menderes University

Dana L. Zeidler, University of South Florida

ABSTRACT:
The aim of this investigation was to examine preservice teachers' epistemological patterns of reasoning about socioscientific issues and their NOS understanding. The focus of the paper is to flesh out the importance of contextualization of Nature of Science (NOS) within the Socioscientific issues (SSI) framework because of the centrality of it plays as a key construct in science education. The emphasis on advancing scientific literacy is placed on a robust understanding and appreciation of NOS, as well as the acquisition of socioscientific reasoning, skills and values. Students' negotiations on socioscientific issues are influenced by a variety of factors related to NOS such as scientific knowledge, data interpretations, and social interactions including individuals' own articulation of personal beliefs. The socioscientific reasoning patterns of PTs, developed in group discussions on each controversial issue, and students VNOS-B responses were used as data source. Results of this study are twofold; first we explored the preservice teachers NOS understandings, second we reported the emergent codes about their epistemological patterns of reasoning about socioscientific issues. Results shows that classroom discussions on science related issues helped students to have better understanding about NOS aspects. Teaching NOS in SSI context rather than presenting as a list of stereotypic knowledge to be learned can help students to see the processes of science that derived from human creativity and imagination.

Investigating the Development of Preservice Teachers' Philosophy and Nature of Technology & Engineering Views

Jerrid W. Kruse, Drake University
Hallie S. Edgerly, Drake University
Jaclyn M. Easter, Grand View University

ABSTRACT:
Although the American Association for the Advancement of Science (AAAS) called for inclusion of the philosophy and nature of technology (PNOT) nearly 20 years ago (AAAS, 1989), PNOT does not enjoy the prominence in the literature that nature of science (NOS) holds. Yet, to achieve inclusion of PNOT in K-12 systems, efforts to educate teachers in PNOT must be undertaken. Therefore, this study sought to understand the impact of PNOT instruction on preservice teachers PNOT views during a course targeting both NOS and PNOT. Using a mixed-methods approach, this study highlights preservice teachers' initial PNOT ideas not aligned to the literature. However, after the course, preservice teachers' views move strongly toward alignment to PNOT literature. Using data from participants, the study explores implications for supporting teachers in learning about PNOT.

Pre-service Science Teachers' Perceptions of Scientific Knowledge

Selin Akgun, Bogazici University
Ebru Kaya, Bogazici University
Sibel Erduran, University of Oxford, UK
Busra Aksoz, Bogazici University

ABSTRACT:
This study focuses on pre-service science teachers' perceptions of "scientific knowledge". The characterisation of "scientific knowledge" is based on Erduran and Dagher's (2014) framework that identified theories, laws and models (TLM) as different forms of scientific knowledge to explain a phenomena about the universe. TLM is meta-level depiction of the structure of scientific knowledge and as such it also explains the growth of scientific knowledge. Our aim was to determine the pre-service science teachers' perceptions of scientific knowledge before and after a teacher training intervention on nature of science (NOS) that included sessions on the nature of scientific knowledge. 15 pre-service science teachers at a public university in Europe participated in the study that was part of a funded project. Pre- and post-interviews were applied to the participants. The data were analyzed using qualitative methods. Each interview was transcribed and coded related to how scientific knowledge was discussed. The findings indicate that before the intervention, pre-service teachers did not have a clear understanding of the nature of scientific knowledge. However, after the intervention, they developed a broader understanding of scientific knowledge that was based on the TLM framework.

Pre-service Teachers' Preference to Apply NOS Aspects and Evidence-based Thinking in their Teaching

Deniz Saribas, Istanbul Aydin University
Gaye Ceyhan, Bogazici University
Doug Lombardi, Temple University

ABSTRACT:
Increasing students' understanding of nature of science (NOS) is among the goals of science education. Investigating pre-service science teachers' tendency and preference for teaching NOS is crucial in this respect. Science teachers' perspective of scientific understanding and their way of teaching is also significant. Therefore, there is a need to include evidence-based thinking and evaluation experiences as well as teaching NOS into teacher education and professional development. In this study, we analyzed group and individual lesson plans (LPs) to gauge their preference of NOS aspect to teach. We also analyzed participant reflections made in their group LPs to probe the way they lead their students to use evidence for scientific explanations. The findings of this study indicated that pre-service teachers have a hybrid understanding of NOS regarding the positions of Version 1 and Version 2. Analyses of group LPs also showed that the participants have appreciated the importance to lead their students to make evidence-based explanations but they used mostly empirical evidence. The results indicated the necessity of restructuring teacher education programs

to enable pre-service teachers gain a systematic understanding of NOS and lead their students think evidence-based and for this purpose design their instructions to create a discourse environment.

Strand 8: In-service Science Teacher Education
Coaching & Co-Teaching
10:15am-11:45am, Hyatt Republic ABC
Presider: Andy Cavagnetto, Washington State University

Catching the Moments – Coteaching to Stimulate Science in the Preschool Context
Pernilla Nilsson, Halmstad University
Colette Murphy, Trinity College, Dublin
ABSTRACT:
An important task for the preschool teacher is to create meaningful learning situations where children have opportunities to experience science. However, many teachers have both weak subject knowledge and a lack of confidence to teach science. The aim of the project presented in this article was to capture how nine preschool teachers developed their learning of and self-confidence in teaching science during a two-year professional development (PD) project while coplanning, coteaching, and coreflecting on their teaching activities. During the project, the preschool teachers' self-confidence and attitudes played an important role for the their approach to science activities. Their collaborative learning and reflection became important for their PD and for the way science phenomena were included in the preschool context. As such, the project is based on opportunities for preschool teachers to develop their ideas about science and to reframe their work with the aim to stimulate children's curiosity for science.

Distance-base Instructional Coaching for Elementary Teachers' Integrated STEM Teaching
SoonChun Lee, Wichita State University
ABSTRACT:
This project involved 27 grade 3-5 teachers from 5 urban schools in a Midwest state participated in a 2-week summer institute for project-based STEM instruction. They also received 6 distance-based STEM instructional coaching sessions by project-hired instructional coaches during the following school year. This is a PD model designed to equip elementary teachers with knowledge and skills to teach science/math and other subjects using an integrated STEM instructional approach and to translate these skills into teaching practice. The distance-based coaching model used in this study is delivered via Google Hangout – a web-based video conferencing software. The results from pre- and post-tests completed by 25 teachers at the start and end of the summer institute showed both teachers' inquiry knowledge and confidence level in teaching STEM significantly improved after 2015 summer institute were maintained throughout 2015-2016 school year. The results also showed that this study demonstrated how distance-based instructional coaching play roles in a PD for teachers particularly. This model of coaching as a form of instructional support is a more sustainable and adaptable than face-to-face instructional coaching and it has a great potential to be replicated for pre- and in service science teachers in other school districts or education institutes.

How Instructional Coach Frameworks Mediate Policy to Practice
Kat Laxton, University of Washington
ABSTRACT:
This paper explains how the leadership of district-level instructional coaches supports teacher learning of pedagogy related to the Next Generation Science Standards. Although instructional coaches are typically thought of as critical change agents in reform, there are few examples in the literature that explain how instructional leaders, like coaches, interact with teachers to improve instructional practice. In this study, we found that re-structuring professional development to a multi-faceted job-embedded coaching model supported teachers in learning reform-related pedagogy. However, the individual teacher interpretations of practice seemed to be linked to how instructional coaches supported teacher learning. This paper proposes four conceptual categories of sense-making that influence how instructional coaches interpret the nature of reform and their roles as instructional leaders. Rodger 0 0 2015-05-29T23:10:00Z 2015-05-29T23:10:00Z 1 129 782 PSESD 15 4 907 14.0 Normal 0 false false false EN-US JA X-NONE

The Impact of Video-based Coaching: Sadie's Story
Janet Carlson, Stanford University
Sadie Skiles, Oakland Technical High School
ABSTRACT:
This case study of Sadie – one teacher in a cohort of 100 early-career teachers from high schools that serve populations comprised of 50% or more students who qualify for free lunch – describes how video-based coaching that complemented a summer PD institute changed how she taught as well as her interest in staying in the teaching profession. The most effective teachers make planning and teaching choices with fluency and automaticity using high-leverage teaching practices such as facilitating productive discourse among students. While a large number of science teachers in U.S. high schools struggle to enact this high-leverage practice effectively, enactment can be learned as this case study will illustrate. It is also important to note that teachers working in schools with large

populations of chronically marginalized and underserved students are in greatest need of learning to use core practices. This need stems from the chronic issues of high turnover of teachers in these schools resulting in students frequently being taught by novices or under-qualified teachers, both of which have a negative impact on learning. It is not insignificant that Sadie has improved her practice and increased her job satisfaction as result of participating in this practice-based professional development program.

Coaching Partnerships for Implementation of STEM Integrated Curriculum ***(Virtual Presentation)***
Tasneem Anwar, University of Minnesota
Gillian H. Roehrig, University of Minnesota
ABSTRACT:
During the recent years STEM integration was recognized beyond just mathematics and science. Empirical evidences also show a positive impact of STEM integration on learning. But the biggest challenge lies in providing STEM specific professional development that can provide teachers with a scaffold for implementing STEM integrated curriculum. Research suggests that coaching can provide a sustained support to science teachers. The collaborative and trust-based nature of instructional coaching model that focuses on the on the "Big four"; behavior, content knowledge, direct instruction, and formative assessment (Knight, 2009) makes it a best fit to support science teachers for the implementation of STEM integrated curriculum. This study focuses on the instructional coaching support provided to the science teachers during the pilot phase of the yearlong project. Specifically, authors explore the impact of coaching support provided to the teams of teachers during summer curriculum development and informal pilot. This exploratory case study provides evidence of developing a strong scaffold for teachers through coaching partnership along with STEM specific professional development. It seems this collaboration may increase over time. Findings of this study affirm Knight's (2009) statement that coaching is a promising approach for accelerating professional learning.

Strand 10: Curriculum, Evaluation, and Assessment
Issues in Physical Science Curriculum and Assessment
10:15am-11:45am, HBG Convention Center 006C
Presider: Joseph S. Krajcik, Michigan State University

A Multilevel Analysis of Changes in Physics Students' Conceptual Understanding using Technology-based Assessment
Yuan-Ling Liaw, FACET Innovations
Jim A. Minstrell, FACET Innovations
Dongsheng Dong, University of Washington
ABSTRACT:
This study is about the effects of use of diagnostic formative assessment to monitor improvements in student conceptual understanding. Multiple short formative assessment while in the leaning experience can be used to monitor potential gains (or losses) in student conceptual performance in students' understanding of key ideas related to force concept. Increased use of formative assessment improves gains in student understanding. Multiple assessment the same day or across time can result in improved performance, if related instructional activities happen between formative assessments. Teacher factors may affect the gains produced by multiple use of formative assessment, but that is still ongoing in the research. In this study, three research questions are addressed: (1) Do gain scores depend on teacher's frequency of use (number of assignments in one cluster idea) of sets? (2) Do effects of students' gain scores depend on the time period between assignment due dates for sets? (3) What teacher-level variables predict the sources of students' gain scores cluster?

Creativity in a Project-Based Physics and Chemistry Intervention
Christopher Klager, Michigan State University
Barbara Schneider, Michigan State University
Joseph S. Krajcik, Michigan State University
Jari M.J. Lavonen, University of Helsinki
Katariina Salmela-Aro, University of Helsinki
ABSTRACT:
Policymakers and science educators have long recognized the need for developing students who can think creatively. However, providing opportunities for creative thinking and problem solving in science classrooms is challenging. Project-based learning is a curricular effort with features that creativity researchers identify as important for fostering creative thought. In this study, ten high school physics and chemistry teachers participated in a project-based instructional intervention. They attended a professional development workshop on project-based learning and collaboratively designed project-based units. Using a single-case design and the experience sampling method to collect data on students' experiences during teachers' business-as-usual instruction and the project-based units, we were able to assess the impact of project-based instruction on student creativity. We found positive effects for use of imagination (effect size = .29) and exploration of different points of view (effect size = .27). These results suggest that project-based learning may be an effective instructional strategy for promoting student creativity in high school physics and chemistry classrooms.

Developing an NGSS-Aligned, LP-based Assessment of Students' Understanding of Matter
Aaron D. Rogat, Columbia University
Lei Liu, Educational Testing Service
ABSTRACT:
We sought to develop a new computer-based science assessment aligned with the Next Generation Science Standards (NGSS) and a learning progression (LP) in order to determine if we could build better measures of student science learning. We selected a core disciplinary idea (Matter) and a central practice (developing and using models) as the target constructs for our assessment prototype that addresses the multidimensional features of science learning. The research question that we are addressing is: Can we effectively assess student thinking about the structure and behavior of matter through computer-based modeling tasks informed by an LP? We report on how students performed on the initial pilot of this assessment, how it corresponds to existing research as well some of the strengths and challenges of probing students' knowledge of matter using modeling items embedded in a task aligned to an LP

Validating an Assessment for Tracking Students' Growth in Understanding of Energy from Elementary School to High School
Joseph M. Hardcastle, AAAS, Project 2061
Cari F. Herrmann Abell, AAAS, Project 2061
George E. De Boer, AAAS, Project 2061
ABSTRACT:
Energy is a critically important topic in the K-12 science curriculum, with many applications in the earth, physical, and life sciences and in engineering and technology. To meet the challenges associated with teaching energy, new tools and assessment instruments are needed. In this work we describe the development of a three-tier assessment instrument designed for measuring students' understanding of energy at basic, intermediate, and advanced levels. Using a bank of 372 multiple choice items targeting 14 different key energy ideas, three assessment instruments were created to test each of the three levels. These instruments were pilot tested with elementary, middle, and high school students and results were analyzed using Rasch modeling. Our findings show that by using linking items the three instruments form a common scale, allowing items and students to be compared across forms. Each instrument was found to contain items with suitable difficulties for students with a range of understandings of energy. Together these instruments form a reliable tool for measuring the growth of students' understanding of the energy concept as they progress from elementary school to high school.

Strand 11: Cultural, Social, and Gender Issues
STEM Learning Beyond the Classroom
10:15am-11:45am, HBG Convention Center 008B
Presider: Leah A. Bricker, University of Michigan

Decoding STEM: The Impact of STEM Outreach Programs on English Language Learners
Stephanie Florence, York University
Isha Decoito, Western University
ABSTRACT:
Science, technology, engineering and mathematics (STEM) disciplines are often considered to be a "gatekeeping" course of study. The language used within these disciplines and their traditional pedagogies - which place emphasis on textbook learning - can be challenging for students, especially those who are learning English at the same time. This case study examines a cohort of English language learners (ELLs) from a larger longitudinal STEM study to consider how school partnerships with STEM outreach programs can offer alternative pedagogical strategies through a hands-on inquiry model to effectively engage ELLs as well as support STEM learning and second language acquisition concurrently. Preliminary findings indicate that the use of hands-on activities for ELLs to explore with their peers provokes positive attitudes towards and interest in STEM subjects. They also allow students to familiarize themselves with conversational language learning which can be extended autonomously by these students to acquire STEM vocabulary.

Effects of Out-door Experiences with Cultural Flavor on Students Achievement in Physics
Tunde Owolabi, Lagos StateUniversity, Lagos, Nigeria
Peter A. Okebukola, Lagos State University, Ojo
Hakeem O Akintoye, Lagos State University, Lagos
Olugbenga G. Akindoju, Lagos State University
Abraham Ologundudu, Lagos State University
Olubunmi B Onafowokan, St. Augustine College of Education, Akoka
ABSTRACT:
This study examined the effect of out-door experiences with cultural flavor on achievement of students in physics. It employed a combination of quantitative and qualitative research approaches to gather data using an intact class of Senior Secondary 3 students in a

public school. Data were gathered through the use of an achievement test, unstructured interview and students' anecdotal notes. Findings revealed that students taught with out-door experiences performed significantly better Fvalue =(3680,p<0.05,df 350) than those students who were restricted to the classroom. Students interviewed and their anecdotal notes also showed the positive impact of out-door learning experiences on students understanding of physics

The Influence of Peer-Led Team Learning on the Recruitment and Retention of Underrepresented Minority Students in STEM Majors
Jeremy D. Sloane, Syracuse University
Julia J. Snyder, Syracuse University
Ryan D. Dunk, Syracuse University
Christina I. Winterton, Syracuse University
Jason R. Wiles, Syracuse University
ABSTRACT:
The President's Council of Advisors on Science and Technology (PCAST) has predicted a deficit of one million college STEM graduates over the next decade and called for diversification of instructional strategies to increase student persistence in STEM. Prior research indicates that active and team-based learning approaches foster environments more conducive to student achievement, recruitment, and retention in STEM fields, and suggests that underrepresented populations may benefit most from these approaches. Peer-Led Team Learning (PLTL) is an instructional model that may hold particular promise in this regard. The present study explores the effectiveness of PLTL in an Introductory Biology course at a large, private university in the American northeast toward increasing recruitment and/or retention of undergraduates in STEM fields with a focus on URM students. High-performing students frequently cite uninspiring introductory courses as a factor in their decisions to leave STEM majors, and previous work suggests that many students – particularly those who are members of underrepresented minority groups – can benefit substantially from small-group learning environments with an instructor who is more like themselves. Analyses have revealed that when students participated in PLTL the gaps in STEM recruitment and retention rates between URM and non-URM students are statistically closed.

Sociomaterial Assemblages in Online Asynchronous Learning Environments
Shannon Burcks, University of Missouri
Marcelle Siegel, University of Missouri, Columbia
Christopher D. Murakami, University of Missouri, Columbia
Rose M. Marra, University of Missouri, Columbia
ABSTRACT:
This case study aims to describe assemblages (Deleuze & Guattari, 1987) in online asynchronous learning environments which support authentic science learning. We asked the Research Question: What is the nature of assemblages shaping student participation in asynchronous learning environments? Our study included 12 senior preservice science teacher students which participated in a 5 day asynchronous online biology unit. Student pairs collaborated online using the virtual environment Supporting Collaborative Inquiry Labs (SCIL). Data sources included discussion posts, and all SCIL related asynchronous communication artifacts. Our analysis was inspired by sociomaterial bricolage (Johri, 2011; Baker & Nelson, 2005) and the 1997 translation of Derrida's (1967) deconstruction with the aim to identify the sociomaterial idiosyncrasies and bring awareness to the fundamental problems that are embedded within the assemblages. Our findings include assemblages that limit student participation and assemblages regarding the use of technology to its full potential. We discuss instances regarding how these assemblages can be oppressive and ways to interrupt and weaken those oppressive assemblages. Our post-humanist stance allowed us to account for how materials impacted the educational practice (Sorensen, 2009). This study helps reshape the culture of science learning by challenging established norms and subsequent marginalization of people (Sewell, 1999).

Strand 12: Educational Technology
Student Attitudes and Impacts
10:15am-11:45am, Hyatt Crockett AB
Presider: Jennifer L. Weible, Central Michigan University

The Cultural Science of Teaching Science Through Digital Tools
Kareem Edouard, Stanford
Bryan A. Brown, Stanford University
ABSTRACT:
The technology education movement includes e-books that can be customized for students. This qualitative study examined 35 students as they customized their own digital books. Using digital photos and videos, each student selected from a folder of diverse options to drag and drop images into their e-book. The images were identical except for the racial of the characters. We discovered that cues about racial authenticity emerged as primary the motivation for students selecting images. Students consistently chose images that reflected their racial, gender, and linguistic identities. The results of this study highlight the need to recognize how racial cues can help students draw deeper connections to digital media if those cues are culturally authentic.

Investigating what Factors May Affect Students' Attitudes toward Clicker Usage in Science Classrooms: An Exploratory Study
Yu-Ta Chien, National Taiwan Normal University
Chun-Hui Jen, National Taiwan Normal University
Sonya N. Martin, Seoul National University
Hye-Eun Chu, Macquarie University
Chun-Yen Chang, National Taiwan Normal University
ABSTRACT:
This study surveyed 11th grade students' attitudes toward the use of clickers in physics classes. Students' gender, social interaction anxiety levels, science achievement levels, preferences toward classroom participation, preferences toward peer learning, and perceptions toward classroom interactions were also surveyed. Based on 106 responses, regression models were constructed to explain students' attitudes toward clicker usage. It was found that students generally hold positive attitudes toward clicker usage. No significant difference was found in students' attitudes toward clicker usage between gender, academic achievement levels, social interaction anxiety levels, and classroom participatory types. Students' preferences towards peer learning and positive perceptions towards classroom interactions were found to be significant factors for predicting their attitudes toward clicker usage. It is noted that clickers are often claimed to be more favorable for students who have a higher level of social interaction anxiety or who do not prefer the verbal participatory approach. However, these claims are not supported by our data. The results suggest that students who are more eager to interact with peers and teachers, regardless of their social anxiety levels or what participatory practices they prefer, might feel more empowered from the use of clickers.

Students' Motivational Expressions and Teacher's Motivational Support in an Online Forum during Open Inquiry
Idit Adler, Bar-Ilan University, Israel
Michal Zion, Bar-Ilan University, Israel
Liron Schwartz, Bar-Ilan University, Israel
Nir Madjar, Bar-Ilan University, Israel
ABSTRACT:
Inquiry-based learning is regarded as pedagogy that motivates students to engage in the excitement of science. However, providing students with an authentic and problem-based experience does not guarantee their engagement. Thus, it is important to understand the dynamic of students' motivational expressions during inquiry, and provide them with the necessary motivational support. The goal of this research is to identify and characterize the students' expressions of motivation and the teacher's motivational support within an online forum during an open inquiry process. The students' and the teacher's postings were examined using content analysis methods based on the Self-Determination Theory. The results of this research indicate that students do not automatically embrace the autonomous characteristic of open inquiry. Their expressions of motivation are dynamic, and effected by the challenges and difficulties they encounter. In contrast, the teacher maintains high levels of autonomy and competence, and intertwines these two components in a strategy we termed guided autonomy. In addition, a positive correlation was found between the teachers' motivational support and the students' expressions of motivation. The results presented in this study are a first step towards the development of research-based educational interventions to support students' motivation within an open inquiry process.

Supporting Preschool Science: The Use of Digital Tools to Promote Children's Engagement in Science Practices
Marion Goldstein, EDC
Danae Kamdar, SRI International
Regan Vidiksis, EDC
Ximena Dominguez, SRI International
ABSTRACT:
Promoting science learning in preschool is an important step to prepare children for later scientific learning, as well as a developmentally appropriate and engaging endeavor that capitalizes on young children's natural curiosity and desire to understand the world around them. With this in mind, a federally funded multidisciplinary team has been working in partnership with teachers and expert advisors to develop, iteratively refine, and evaluate an innovative curricular program to promote science teaching and learning in early childhood. The proposed session will report on findings from a randomized controlled study to evaluate the promise of the program, focusing primarily on science practices and how digital tools were used in conjunction with hands-on activities to promote children's engagement in Observation and Description, Prediction, and Experimentation. The session will highlight the particular features of digital activities that were more or less successful at supporting science practices, and how and when additional teacher support or scaffolding was critical to support such engagement. In doing so, the session will also share findings about how technology and media in general can support science learning in preschool classrooms.

Strand 13: History, Philosophy, and Sociology of Science
Elementary Students' and Teachers' Views of Nature of Science, Scientific Inquiry and Socio-scientific Issues
10:15am-11:45am, Hyatt Seguin AB

Presider: Valarie L. Akerson, Indiana University

A Cross Sectional Study of Elementary Students' Understanding of Nature of Science and Scientific Inquiry
Selina Bartels, Illinois Institute of Technology
Judith S. Lederman, Illinois Institute of Technology
ABSTRACT:
The teaching of scientific literacy is the primary goal of elementary science education. Scientific literacy is composed of the overall understanding of what science is and how scientific knowledge is developed. The purpose of this study was to see if elementary students' understandings of science, scientists and how scientists do their work changes from grade one to grade five of elementary school. The study draws on a sample of 338 students from 18 different classrooms situated in six different schools in both urban and suburban areas of a large Midwestern city. Students' understandings of science, scientists and how they do their work was measured through a valid and reliable oral protocol entitled Young Children's Views of Science (YCVS). The YCVS assesses students' understandings of the aspects of scientific inquiry (SI) and the nature of science (NOS) that young elementary students are able to understand. Results indicated that there are very few gains in NOS and SI understandings between grades one and five in the schools included in this study. None of the schools in this study made significant gains for all of the nine aspects measured in this study. Overall, students' understandings of science, scientists and how they do their work did not significantly change from grade one to grade five. This study shows that students' scientific literacy is not being developed throughout elementary school. Therefore, the teaching of scientific literacy in an explicit and reflective manner should be the focus of preservice elementary school education.

Improving Nature of Science Instruction in Elementary Classes with Educative Curriculum Materials and Trade Books
Jeanne L. Brunner, University of Massachusetts Amherst
Fouad Abd-El-Khalick, University of North Carolina, Chapel Hill
ABSTRACT:
The present study investigated the impact of elementary science trade books and educative curriculum materials on teachers' views of nature of science (NOS), changes in teaching practices during read-alouds of the trade books, and students' interaction with the NOS concepts during the read-alouds. Changes were tracked across three levels of intervention, which explored the effects of trade books modified to include explicit references to NOS and additive effects of educative curriculum materials that accompanied the modified books. The educative curriculum materials aimed at supporting the teachers' development of more informed views of NOS, as well as guiding their pedagogical decisions during the read-aloud. Every participating teacher changed their views from less informed to more informed on at least one of the NOS aspects, as well as changing their teaching practices to include more references to NOS. Additionally, at least some students in every class improved their views on one or more of the targeted aspects of NOS. These results point to the effectiveness of using educative curriculum materials to support NOS instruction during read-alouds, as well as the need for the development of more curriculum materials that specifically support NOS teaching and learning.

Nature of Science and Elementary Teachers: Do Changes in Conceptions and Teaching Persist Eight Years following a Prolonged Professional Development Program?
Theresa A. Cullen, University of Oklahoma
Valarie L. Akerson, Indiana University
ABSTRACT:
Sixteen K-6 teachers participated in a three year Nature of Science (NOS) professional development program that included 2 intensive weeks each summer and one day a month during the school year. This professional development program included instruction on inquiry, physics science content, and NOS teaching techniques. Following the program, teachers not only incorporated NOS techniques in their teaching but also engaged in action research projects to evaluate the effectiveness of these strategies on student knowledge. We investigated whether long-term change took place. Authors (2009) and participants remained in touch with researchers long after official funding had ended via social media and community interactions. The researchers followed up with participants 8 years after the program to see whether and how they were teaching nature of science. As part of the follow up all teachers were invited to participate in an on-line survey and to follow up with interviews. Nine teachers filled out the online survey which included the VNOS-D2 (Views of Nature of Science) and five completed in-depth interviews. We found that they were still including NOS in their teaching, continued to struggle with some misconceptions, and struggled to keep science in the elementary curriculum.

No Child Too Young: An Exploratory Teacher Research Study of Socioscientific Issues Implementation at the Elementary Level
Sami Kahn, Ohio University
ABSTRACT:
Research on the Socioscientific Issues (SSI) framework presents compelling evidence of its ability to provide contextualized, student-centered science learning as preparation for informed citizenship. However, of the few SSI studies that have been conducted in elementary classrooms, none provide insight as to whether the pedagogical demands of SSI warrant modification or refinement when implemented with young children. Through this exploratory teacher research study, a series of SSI units were developed and implemented in the teacher-researcher's first, second, and fourth grade science classrooms over a one-year period. Data included a

reflective journal which was analyzed using thematic analysis across grade level cases, along with artifacts of student work, student evaluations, and peer debriefing to enhance validity. Results suggest that while SSI implementation provided a critical real-world context for science learning and student discourse, several developmentally-influenced challenges were evident including students' difficulties in shifting from emotional to cognitive bases of argumentation, problems with source monitoring, unintended activation of student fears, confusion between real and imaginary scenarios, and uneven emotion regulation. Findings and recommendations, discussed in light of leading theories of child psychosocial development, provide a foundation for future research on curricular and pedagogical supports that can facilitate successful elementary SSI implementation.

Strand 15: Policy
Policy and the Role of Teachers: Teacher Preparation and Teacher Leadership
10:15am-11:45am, HBG Convention Center 006B

The Relationship of Teacher Certification Preparation and Student Science Achievement: Analysis with NAEP 2011 Data
Feng Jiang, University of Arkansas
Denise Ariola, University of Arkansas
ABSTRACT:
Alternative certification is an important and debated topic in teacher education and educational policy. Studies have been conducted to compare student performance of alternatively certified teachers with traditionally certified teachers. Most of the studies have been focused on math and literacy, but very few on science. Moreover, previous studies were either based on national data or distinct state data. By using multilevel analysis based on NAEP data, we took the states' contexts into account, but also provided comparable results. Overall, alternatively certified teachers perform equally well as traditionally certified teachers. However, results also show considerable differences among states. There are more states, where alternatively certified teachers perform better than traditionally certified teachers, than the opposite. Our results also revealed that alternatively certified teachers did not have a stronger advantage in states having more alternatively certified teachers.

Raising Test Scores Versus Teaching Thinking: Teachers' Views On How Simultaneous Policies Affect Practice
Anat Zohar, Hebrew University of Jerusalem
Vered alboher Agmon, Hebrew University of Jerusalem
ABSTRACT:
This study examined the fate of a policy advocating instruction of higher order thinking (HOT) under a regime of high stakes testing as viewed by a group of senior science teachers. The qualitative study is based on semi-structured interviews with 20 senior science teachers in Israeli junior high schools. The findings show that the simultaneous requirements for a rapid raise in test scores and for fostering HOT created considerable tensions and conflicts. Consequently, instruction of HOT was compromised in two fundamental ways: (a) the findings indicate that on the face of it, the policy advocating rapid increase in test scores and the policy advocating instruction of HOT did encourage teachers to teach for thinking. However, when this took place under a regime of high stakes testing, instruction of HOT had taken the form of "mechanical learning", implying rote learning and drilling students in answering HOT items. (b) moreover, under such circumstances, learning of low-achieving students had been compromised. Despite a policy stating the need to narrow achievement gaps, and despite sound pedagogical knowledge concerning how to teach diverse student populations, the pressure to raise test scores caused teachers to refrain from teaching HOT to low-achieving students.

Developing Math/Science Teacher Leadership: A Consensus Approach to Evaluating Program Quality
Jody Bintz, BSCS
Jodie Galosy, Knowles Science Teaching Foundation
Barbara Miller, Education Development Center, Inc.
Lindsey Mohan, University of Notre Dame/University of Texas Austin
Audrey Mohan, Biological Sciences Curriculum Study
ABSTRACT:
Building a national pipeline of math/science teacher leaders ready to serve in a variety of roles is very much a work in progress. If teacher leadership becomes standard practice, math and science teachers would have multiple opportunities to exercise formal and informal leadership across their careers and leadership development would be a part of their professional learning progression (National Comprehensive Center for Teacher Quality, 2010). This project is focused on synthesizing research and practice in math/science teacher leadership development programs. The purpose of this project is to build consensus on the key attributes of math/science teacher leadership development programs, identify patterns in how these programs define and measure program quality, and describe evidence of the effectiveness of math/science teacher leadership development programs. Of the 76 research abstracts and 70 program descriptions vetted, 17 research articles and 15 articles describing programs met the criteria for the study. These articles were summarized and served as the basis for online and face-to-face discussions among selected leaders in math/science teacher leadership. Our session will include a discussion of findings and recommendations for future research and development.

Science Teacher Leadership Practice: A Theory for Guiding Increased Attention to Teacher Leadership in Policy
Todd Campbell, University of Connecticut
Julianne A. Wenner, Boise State University
Latanya Brandon, University Connecticut
ABSTRACT:
Current shifts in educational reform have led to increased interest in teacher leadership (TL). However, a recent comprehensive review of research on TL over the last decade characterized the literature as 'somewhat atheoretical', and it was noted that even when researchers do employ theory, there is little agreement or consistency. Therefore, the purpose of this study was twofold: 1) To develop a theory of TL rooted in empirical literature that incorporates components from social practice theory and identity authoring; and 2) To apply this theory to a study of TL in situ in order to refine this developing theory. The initial model proposes competences, performances, and recognition that are particular to three communities of practices (teacher, teacher leader, and school leader). Exploring the work of three elementary science TLs and applying our model to data collected, findings indicate that our model provided insight into TL by identifying specific competencies and performances relevant to TL in particular communities of practice, highlighted the importance of public recognition of TL, and ascertained structural factors which can greatly impact TL. Our developing theory of TL, further refined by the data, holds promise for informing policy and practices for (science) TL.

Concurrent Session #12
1:00pm – 2:30pm

Administrative Sponsored Session
Admin Symposium: Maximizing Insight from Mixed Methods Research: A Range of Perspectives
1:00pm-2:30pm, Hyatt Seguin AB
Presenters:
Joseph A. Taylor, BSCS
Zahra Hazari, Florida International University
Valerie K. Otero, University of Colorado, Boulder
William R. Penuel, University of Colorado
ABSTRACT:
This interactive 90-minute session, sponsored by the Research Methods RIG, will feature 15-20 minute talks from 3 researcher panelists who have successfully incorporated mixed methods approaches into their work. Members of the Research Methods RIG steering committee will provide a session introduction and summary thoughts about the collective presentations. There will be time between presentations and at the end of the session for audience comments and questions: The focus of each panelist's talk will be: 1. How do you define "mixed methods" research? 2. How do you integrate qualitative and quantitative data and methods to maximize the insights that can be gained from research?

Strand 1: Science Learning, Understanding and Conceptual Change
Explaining, Reasoning and Problem Solving in Science
1:00pm-2:30pm, HBG Convention Center 006D
Presider: Binaben H. Vanmali, Arizona State University

Extracting and Visualizing the Structure of Verbal Explanations
Steffen Wagner, Humboldt-Universität zu Berlin
Burkhard Priemer, Humboldt-Universität zu Berlin
ABSTRACT:
Models and explanations are essential for connecting phenomena and theory in science, and hence, in science education. Research has shown that science students struggle when applying their theoretical knowledge to the real world. We present an approach to capture the structure of verbal explanations in order to locate students difficulties. We developed a coding scheme to create so-called categorized concept maps using n=20 explanations of the phenomenon of the apparent depth. We tested our coding scheme on a second smaller sample. To illustrate our procedure, we use an example taken from a science textbook explaining the same phenomenon and present the coding sequence and a visualization of the explanation structure. Our procedure turns out to be a working, reliable instrument that can be used fruitfully to evaluate students explanations.

How Observation of Contrasts can Build Knowledge that Influences Reasoning
Maura B. Foley, University of Maine
Jonathan Shemwell, University of Maine
ABSTRACT:
Knowledge of contrasts between phenomena can influence how people think and reason about them, so learning contrasts is important in school science. An effective way to learn using contrasts is to differentiate phenomena that are presented side-by-side. Little is known about how the knowledge that results from such activities may influence scientific reasoning, particularly reasoning with evidence. We studied this influence in the context of a species identification task. Ten participants were shown photos of an unknown plant and thought aloud as they identified it using a field guide. The guide contrasted the target plant's features from those of an otherwise similar alternative. The think aloud protocols showed how participants learned the target features as contrasts. Moreover, they showed how they continued to refer to the contrasts in their thinking about the features when looking at the photographs of the unknown plant and when using the photographs as evidence of the plant's identity. Thus, knowledge of contrasts can persist in and influence student thinking in valuable ways. Further, instruction that uses contrasts may help students reason about phenomena.

Effective Use of Contrasts in Learning Strategic Knowledge for Problem Solving
Thanh K. Le, University of Maine
Jonathan T. Shemwell, University of Maine
MacKenzie R. Stetzer, University of Maine
ABSTRACT:

Contrasts can help learners build knowledge needed for reasoning and problem solving. Within instruction, a number of cases, called contrasting cases, can be used to indicate key scientific knowledge in the form of a commonality that is present across a range of contexts. Contrasting cases instruction have been shown to increase the learning of a variety of science topics, such as projectile motion and electromagnetism. Much of the current literature on learning with contrasting cases is confined to instruction comparison. Few studies focus on how students use contrasts to build scientific knowledge. Understanding how students effectively use contrasts is important because it can inform task directives. Thus, the present study was conducted to investigate how students effectively use contrast to build strategic knowledge useful for problem solving. College students were audio-recorded as they worked in groups to analyze a set of contrasting cases. Analysis showed three processes contributing to effective contrast use: (1) noticing and using a primary contrast, (2) focusing on the cause of the differences in the cases versus the effects, and (3) making good use of a negative case. Implications for task directives, such as written instructions and teachers moves, to support optimal contrast use are discussed.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Communication and Reasoning
1:00pm-2:30pm, HBG Convention Center 007A

"Why Do We See Stars Only at Night?": Exploring Children's Everyday Thinking in Science
Ashley N. Murphy, West Virginia University
Melissa J. Luna, West Virginia University
ABSTRACT:
Reform efforts in science education acknowledge the importance of teachers attending to their students' everyday thinking. However, as a field, we have limited knowledge of the productive beginnings of scientific understanding in children's thinking and how these beginnings may be assembled to form coherent explanations of phenomena in the natural world. This study addresses this gap in knowledge by investigating two elementary students' everyday thinking about why stars are visible in the night sky but not in the day sky in order to identify the productive beginnings towards understanding the patterns of movement of the sun, moon, and stars as seen from Earth. This study maps the cognitive resources evident in children's everyday thinking that they draw on, try out, and refine in pursuit of a coherent explanation of this disciplinary core idea.

An Online Mentoring Model Based on the First Hand Information from Student-scientist Dialogues
Gokhan Ozturk, Middle East Technical University
Carol L. Stuessy, Texas A&M University
Bugrahan Yalvac, Texas A&M University
ABSTRACT:
In this study we investigated how scientists and students engaged in scientific inquiry and the characteristics of their online interaction as they conducted authentic scientific investigations. Revealing the educational, social, and cultural means of interaction in this student-scientist partnership can help us, as educators, to better understand the essence of the nature and culture of scientific practice from the practitioners' perspectives. The units of analysis for this study are naturally occurring dialogues between student groups, usually four in number, and including their assigned scientist. The sample for the analysis was selected from 36 inquiry groups, which included more than 140 students and 36 scientists. A grounded theory research approach was employed and the data obtained from the student-scientist dialogues were analyzed using constant comparative method. A model representing the mentoring progress and its components was generated. According to the model context, initial phase of inquiry, intervening conditions, social function of scientist mentor, and outcome of investigation are components of the online mentoring we investigated and they are related to the central phenomenon called dialogs about nature of science.

Communicating about Socio-Scientific Issues: UK Students' Mapping of the Badger - Cattle Controversy
Andri Christodoulou, University of Southampton
Paul Davies, UCL Institute of Education
Marcus Grace, University of Southampton
Ralph Levinson, UCL Institute of Education
Joanne Nicholl, UCL Institute of Education
Willeke Rietdijk, University of Southampton
ABSTRACT:
Recently there has been increasing attention to the educational potential of Socio-Scientific Issues within science education. Using Habermas' (1984) Theory of Communicative Action a small-scale qualitative study design was employed to explore how a group of 13 Biology school students communicate about the badger – cattle controversy in the UK and the types of communicative strategies such as those put forward by sincerity, normative rightness and propositional truth claims that can be employed in order to achieve undistorted communication, developing consensus and understanding. The findings suggest that the way in which the sequence of activities were set up based on mapping controversies, group discussion and online communication allowed students to focus on the question explored, identify differences in their positioning and knowledge base and raise questions for further research and

investigation. In this way a model of undistorted communication about an SSI containing scientific uncertainties and social controversies was created. Within this model of undistorted communication, both scientific uncertainties and social controversies are made explicit through mapping (raising questions) before blogging (more considered reflective discourse), which then encourages epistemological depth and a consensus on what the main issues are. Implications for teaching and learning using SSIs are discussed.

Students' Recognition of the Educational Demands in Relation to a Socioscientific Issue Task
Mats G. Lindahl, Linnaeus University
Anne-Mari M. Folkesson, Linnaeus University
Dana L. Zeidler, University of South Florida
ABSTRACT:
Students' difficulties in interpreting what counts as knowledge have been addressed in past educational research. As curricula have changed towards progressivist pedagogy the difficulties have deepened. In science education, the Socioscientific framework, integrating different knowledges and discourses, exemplifies this development. Here, the diffuse boundaries between school subjects and other fund of knowledge leads to considerable difficulties for students to interpret what is expected from them. The present study aims to explore students' recognition of what knowledge or meaning they are requested to produce in a context with weak classification. We use Bernstein's concepts of recognition rules and classification to analyse how 15-16 year-old students develop their discussions in groups of 4-6 students. When students recognize the educational demands they integrate different discourses in their discussion and use both universalistic and particularistic meanings to produce new understandings. When students do not understand the recognition rules they keep discourses apart as in a traditional school task, answering questions or just exchange of personal opinions. And, by keeping universalistic and particularistic meanings apart the dynamics of an exploring SSI discussion is inhibited and the development of socioscientific reasoning is inhibited. The results can provide new possibilities to guide students towards a fruitful SSI-discourse.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Influencing Student Interests
1:00pm-2:30pm, Hyatt Crockett AB
Presider: Jennifer L. Weible, Central Michigan University

Context, Content and Problemorientation - Three Variables Influencing Students' Situational Interest and Understanding in Chemistry
Sebastian Habig, University of Duisburg, Essen
Helena Van Vorst, University of Duisburg, Essen
Elke Sumfleth, University of Duisburg, Essen
ABSTRACT:
Context-based science education seems to be an appropriate way to catch students' interest regarding scientific topics and to foster their understanding. However, there are many factors like context characteristics or task formats, which have to be considered when context-based learning environments are designed. In addition, previous studies point out that positive effects of contextualization depend on the underlying content areas of a learning task as well. This variety of factors might explain the ambivalent findings regarding context-based learning in the research literature. Based on previous research a study with 614 ninth-graders of German secondary schools has been conducted. Within a 2x2x2 study design the variables context characteristic, task format and content-area were systematically varied and their effects on students' situational interest and understanding were investigated. First results show that the effectiveness of context-based learning tasks depends on how common a context is to students and whether it is problem-based or not. In addition, the effect of the underlying context is moderated by the students' initial individual interest.

Does Interest Have an Expiration Date? Stability of Students' Questions as Resource for Context-based Learning
Hani Swirski, Technion-Israel Institute of Technology
Ayelet Baram-Tsabari, Technion
Anat Yarden, Weizmann Institute of Science
ABSTRACT:
Context-based approaches can bring science learning closer to student's life and interests. However, the relevance and stability of interest in specific contexts to different groups of learners are not well studied. Thus, the main goal of this presentation is to examine the stability of interest in science, as reflected by student questions, and similarity between different student groups, with regard to gender and grade level. Over 2300 questionnaires were collected in two waves: in 2007 and in 2016. In each, 4-12th graders marked their interest in studying the answer to specific science questions, which were either frequently asked questions, individual students' questions or science textbook questions. Students were blind to the questions source. Findings indicate that students' interest in science remains relatively stable over almost 10 years. Moreover, students' interest in frequently asked questions and in individual student questions was found significantly higher than interest in textbook questions. The results indicate that questions asked by some students can be incorporated into learning materials in order to enhance the relevance of science to other students' lives and build on their existing interests in science.

Influencing the Self-efficacy and Identity of Students in a Pre-engineering Robotics Program
Brenda R. Brand, Virginia Tech
Takumi Sato, Virginia Tech
Whitney R. Wright, Virginia Tech
Anza Mitchell, Virginia Tech
ABSTRACT:
This study presents the influence upon self-efficacy and identity of high school students in the first-year of a longitudinal study of a pre-engineering robotics program. The program is situated in the Mississippi Delta in a school district with a majority African American population and partner Historically Black College and University (HBCU). We drew upon self-efficacy (Bandura, 1994) and identity theory (Gee, 2001) as frameworks to inform our study. We used modified Longitudinal Assessment of Engineering Self-Efficacy (LAESE) and Attitude Toward Science Inventory (ATSI) survey instruments as pre and post measures given at the beginning of the program and after the completion of the first season along with semi-structured interviews as primary data sources. Survey results showed that the robotics program had positive influences leading to increase in self-efficacy and identity for some while and raised new concerns for other students. Interviews revealed the importance of the curricular design and instruction and social factors that support students in STEM endeavors. Influencing self-efficacy and identity is a complex process and not easily accomplished in one year as K12 students need sustained opportunities for robust learning experiences in order to influence self-efficacy and identity.

NGSS Aligned Problem-based Instruction: Helping all Students Understand Ecology
Amanda L. Gonczi, Michigan Technological University
Brenda G. Bergman, Michigan Tech University
Stephanie Tubman, Michigan Tech University
Jacqueline E. Huntoon, Michigan Technological University
ABSTRACT:
This quantitative study had two goals. The primary goal was to determine the influence of a problem-based unit in ecology to support middle school student learning. A second goal was to determine the mediating role of an interest in nature and the environment on learning. A developed unit was implemented in two schools over six weeks. Students took a 16-item cognitive assessment prior to and following the unit. In addition, students answered five survey items to gauge their initial interest in nature before the start of the unit. Matched data for 147 students was analyzed using paired t-tests and Pearson's correlation. There were significant learning gains from pre-to post-unit implementation. There was no correlation between student interest in nature and change in test score. These findings suggest problem-based learning is an effective method to help middle school students learn ecological principles and can overcome the barrier of low student interest.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Language and Literacy Issues in Science Teaching and Learning
1:00pm-2:30pm, HBG Convention Center 007B
Presider: Irene U. Osisioma, California State University

Efficacy of Multiple Vocabulary Strategies in High School Anatomy for Bilingual Learners
Angela Chapman, University of Texas Rio Grande Valley
Revathi Srinivas, The English and Foreign Languages University
Paul Sale, University of Texas, Rio Grande Valley
ABSTRACT:
This research study investigated the efficacy of an anatomy curriculum embedded with multiple instructional strategies designed to help students develop a deeper meaning of vocabulary in a unit on the cardiovascular system. The instruction was delivered so that classroom teachers and undergraduate students in a math and science methods course could observe the teaching. This study was conducted in two schools in the southwestern United States that serves a predominantly Hispanic population. The findings demonstrate that vocabulary strategies, including first language (L1), help students better acquire vocabulary as demonstrated through significant learning gains on pre- and post-tests. In addition, we offer a conceptual model for testing curriculum that helps students and teachers learn.

Supporting Literacy as Scientific Practice
Mon-Lin Ko, Learning Sciences Research Institute University of Illinois, Chicago
Susan R Goldman, Learning Sciences Research Institute University of Illinois, Chicago
Cynthia Greenleaf, Strategic Literacy Initiative WestEd
Willard Brown, Strategic Literacy Initiative WestEd
ABSTRACT:

The Next Generation Science Standards (NGSS Lead States, 2013) supports science learning as engaging in scientific practices. Teaching science in this way requires shifting students from learning about science ideas to figuring out how and why a phenomenon happens, and the evidence that supports these claims. Although both the design of curricular materials and professional learning experiences for teachers aim to support the students in collecting empirical data as supporting evidence for constructing explanations and models, texts have been largely overlooked as tools for knowledge building in science classrooms. In this presentation we draw on our work over the last 5 years with secondary science teachers and present classroom cases of teachers supporting reading as scientific practice. We describe 4 key facets of engaging in reading as scientific practice: making the conventions of science texts explicit, supporting the thinking and reading processes through metacognitive inquiry, and using texts to problematize and construct explanations for real-world phenomena.

Understanding Beyond the Words: How Language and Ideology Impact Teacher's Understanding of Students' Knowledge
Bryan A. Brown, Stanford University
Catherine Lemmi, Stanford Universtiy
Andrew Wild, Stanford University
Lynne Zummo, Stanford University
Quinten Sedlacek
ABSTRACT:
As teachers evaluate students' responses, the belief system they use to make sense of students' work becomes critical. This focus group interview study (n=25) of high school science teachers examined teachers' language ideology in science. Teachers were asked to evaluate the accuracy of students work by watching videos of lessons and written samples of students' work. We coded teachers' responses into two prominent categories—Binary Thinking and Spectrum Thinking. When using Binary Thinking teachers viewed language and concepts as either completely correct or incorrect. When using Spectrum Thinking teachers viewed components of language and concepts as being partially correct. We found that teacher used each approach inconsistently. We discovered that teachers used both models inconsistently and influenced each other.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Interdisciplinary Learning and Cognition
1:00pm-2:30pm, HBG Convention Center 007C
Presider: Rebekka Darner Gougis, Illinois State University

Academic Success in STEM: Thanks to Visual Model Comprehension?
Thomas Dickmann, University Duisburg, Essen
Stefan Rumann, University Duisburg, Essen
Maria Opfermann, University Duisburg, Essen
ABSTRACT:
The increasing drop-out rates for science-related university studies during the last decades (Chen, 2013) have led research to investigate reasons for this drop-out and ways to support student's academic performance. In this regard, our study focuses on visual model comprehension as a predictor of academic success in chemistry and engineering and on the question, which individual learner prerequisites, on the other hand can predict visual model comprehension. Thereby, the following questions are of paramount interest for us: Is there a difference between chemistry and engineering students regarding their visual model comprehension and its predictors? Which role does domain-specific knowledge play in this context? Our study focuses on the university entry phase of science-related courses of study. First results of 262 students, who take part in a long-term project, indicate that domain-specific knowledge, figural and verbal reasoning as well as spatial ability are able to predict visual model comprehension. The latter, in turn, relates to academic success significantly. Moreover, our findings indicate that chemistry and engineering students differ with regard to their individual prerequisites with which they start their university entry phase.

How does Subject Specific Prior Knowledge Predict Study Success in Biology and Physics?
Torsten Binder, University of Duisburg, Essen
Heike Theyßen, University of Duisburg, Essen
Angela Sandmann, University of Duisburg, Essen
Philipp Schmiemann, University of Duisburg, Essen
ABSTRACT:
In STEM-related fields of study a high number of students drop out of university without earning a degree. Therefore, factors for study success need to be found to improve study conditions effectively. Our project analyses four types of prior knowledge based on the model by Hailikari (2009) and the influence on students' study success in biology and physics. We assume that these types of knowledge predict academic success differently for biology and physics courses as shown for other subjects in previous research. To assess students' prior knowledge at the beginning of first semester we administered four specific tests for each type of knowledge and subject. Confirmatory factor analysis using IRT models confirm a four-dimensional structure which reflects the four knowledge types

in both subjects. Regression models indicate empirical evidence for differential predictive power of the knowledge types between the two subjects. In comparison, the predictive power of the prior knowledge was even superior to that of HSGPA. Our finding could provide information to improve study conditions inter alia.

Introductory Biology Students' Use of Rubrics to Engage in Metacognition and Enhance Understanding
Jaime L. Sabel, University of Memphis
Joseph Dauer, University of Nebraska, Lincoln
Cory T. Forbes, University of Nebraska, Lincoln
ABSTRACT:
Providing feedback to students as they learn how to integrate individual concepts into complex systems is an important way to help them to reach robust understanding, but it is difficult in large, undergraduate classes for instructors to provide feedback that is frequent and directed enough to help individual students. Various scaffolds can be used to help students engage in self-regulated learning, evaluate their work and their ideas, and generate internal feedback to improve their learning. This study examined the use of post-assignment scoring rubrics with added reflection questions and instruction as scaffolds for engaging undergraduate students in self-regulated learning. Study findings show that both the rubrics and reflection questions helped students to engage in metacognition and reach greater understanding of biological concepts. Further, students who received additional instruction on the use of the scaffolds changed how they used the rubrics and, by the end of the semester, were using the rubrics in significantly different ways and scored significantly higher in total course points than students who did not receive the instruction. These findings have important implications for the design of scaffolds within biology courses that will support students in engaging in metacognition and enhancing their understanding of biological concepts.

The Influence of Spatial Aptitude on Undergraduate Students' Tree-thinking Abilities
Yi Kong, University of Texas, El Paso
Jeffrey Olimpo, University of Texas, El Paso
ABSTRACT:
Research suggests that possession of tree-thinking skills is essential for understanding the evolutionary process. While experts are adept at acquiring and utilizing these skills, undergraduates often are not. Despite the emergence of interventions designed to enhance students' tree-thinking abilities, little remains known about the various cognitive and non-cognitive factors mediating this outcome. To address this concern, the present study employed a quasi-experimental, quantitative approach to explore the influence of spatial aptitude (measured via the Mental Rotation Test) on undergraduate students' (n = 312) tree-thinking skills preceding and following their participation in either a traditional or tree-intensive introductory organismal biology curricular module. Students' gender and prior tree-learning experiences were likewise considered due to their established role as positive correlates of visuospatial abilities and understanding of phylogenetic trees, respectively. Results of a multiple linear regression (MLR) analysis indicated that spatial aptitude and prior experiences involving evolutionary trees uniquely predicted students' initial tree-thinking abilities (measured via the MUET survey). A posteriori correlation analyses demonstrated a significant, mediating role of spatial aptitude on pre-MUET performance among those individuals without prior exposure to trees. Conversely, module format (traditional vs. tree-intensive) and pre-MUET score were found to uniquely predict students' performance on the post-MUET assessment.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Faculty/Instructor Professional Development and Assessment of Instruction
1:00pm-2:30pm, Hyatt Presidio ABC
Presider: Mary M. Atwater, University of Georgia

Affordances and Limitations of Collaborative Professional Learning in Higher Education Biology Teaching
Anuschka Neuwald, University of Wisconsin, Madison
ABSTRACT:
A need for change in undergraduate biology education has been identified, but missing from larger efforts to improve undergraduate education are guidelines for how to support instructors' professional learning to change teaching practices. I am exploring one possible support structure by studying a group of seven biology instructors that are engaged in a collaborative process modeled after lesson study, which is a form of cyclical professional learning activities. The purpose of this qualitative case study is to examine the micro-processes of this collaboration and how these micro-processes afford, limit, and challenge the ability to change one's teaching practices. Data analysis shows inquiry-based collaborative professional learning can be difficult to implement in higher education settings where teaching, problems of practice, and long-term engagement with professional learning activities are not the norm. This collaborative process appears to create an environment that challenges instructors conceptually, culturally, and professionally. Therefore, these findings will be important for identifying parameters that could support or impede collaboration and instructional improvement among science educators in higher education. Furthermore, the results will help reevaluate teaching and learning at the undergraduate level in hopes of building a continuum from K-12 to college.

Congruence of Faculty Perceptions of Learning and Instruction Prior to Engagement in Professional Development Programs
Robert Idsardi, University of Georgia
Jenna Wingfield, University of Georgia
Blake Whitt, University of Georgia
Paola Barriga, University of Georgia
Paula Lemons, University of Georgia
Marguerite Brickman, University of Georgia
Julie A. Luft, University of Georgia
ABSTRACT:
Instruction that uses an active learning approach is one way to improve undergraduate learning, however, STEM faculty often find this form of instruction challenging to implement. This research project focuses on understanding the change process of faculty, as they learn about active learning instruction through different professional development (PD) programs. The research question driving this study asks, in what ways are faculty perceptions of student learning congruent with faculty orientations towards active learning prior to engagement in STEM-PD programs? Using a theoretical framework of personal theories, we found faculty have a range of perceptions of student learning and orientations towards active learning. We identify problematic combinations of learning perspectives and instructional orientations faculty may enter STEM-PDs with, and discuss how STEM-PDs might address these existing perspectives and orientations.

Similarities and Differences Between STEM Disciplines Regarding Values of Skills and Exposure to Teaching Practices
Gili Marbach-Ad, University of Maryland
Carly Rietschel, University of Maryland
Katerina Thompson, University of Maryland
ABSTRACT:
Employers of undergraduates from Science, Technology, Engineering, and Mathematics (STEM) programs report that students frequently lack important workplace skills (e.g., collaboration and writing skills). Therefore, there have been widespread calls for STEM education reform emphasizing evidence-based teaching approaches (e.g., active learning) over passive teaching modes (e.g., extensive lecturing). In light of these calls, universities have begun shifting to models of teaching that incorporate evidence-based approaches. This has necessitated the development of assessment methods that can accurately measure the impact of changing teaching practices. In this regard, our Survey of Teaching Beliefs and Practices for Undergraduates (STEP-U) assesses how much students value skills needed for the workplace (e.g., scientific writing), as well as student experiences with teaching practices thought to reinforce such skills (e.g., writing assignments). In the present study, we perform validation tests and compare findings from STEP-U responses from students belonging to five STEM disciplines: Biological Sciences, Chemistry, Physics, Mathematics and Computer Science. Our analyses identified some similarities among disciplines, including attributing a low value to memorization and retention skills. We also observed differences, for example, students in Computer Science, a discipline categorized as applied, placed a higher value on groupwork relative to other disciplines.

Supporting Undergraduate STEM Educators' Instruction: Examining the Participation of Faculty/Instructors in Professional Development Programs
Jenna L. Wingfield, University of Georgia
Robert Idsardi, University of Georgia
Blake Whitt, University of Georgia
Paola Barriga, University of Georgia
Paula Lemons, University of Georgia
Marguerite Brickman, University of Georgia
Julie A. Luft, University of Georgia
ABSTRACT:
Undergraduate STEM educators frequently have instructional goals focused on higher order thinking for their students. Unfortunately, their instructional methods often constrain students in terms of meeting these goals. Active learning helps amend this inadequacy. To facilitate undergraduate STEM educators in their teaching endeavors, a University has initiated differently structured professional development programs that promote active learning. This study pertains to faculty who are participating in these programs, and is being conducted to understand their participation in the different PDPs and how they change throughout the course of the PDP .The research questions this study addresses are: why do faculty attend various PDPs, what are faculty orientations towards active learning and teaching, and how will these change while faculty participate in the PDP? Qualitative data consists of semi-structured interviews that probed faculty experiences and views regarding the instruction of STEM undergraduates. We find that faculty have a variety of reasons for attending a PDP, ranging from being assigned a new classroom to wanting to improve their teaching.Additionally faculty/instructors' orientations towards active learning are varied and personally constructed, and heavily based on prior experiences. These differences lead us to suggests PDPs should not be conceptualized as "one size fits all" programs.

Strand 6: Science Learning in Informal Contexts
Identity Development through Informal Learning
1:00pm-2:30pm, HBG Convention Center 006B
Presider: Megan Ennes, North Carolina State University

Examining the Influence of Participation in Citizen Science Projects on Participants' Identity with Respect to Science: A Study of 70 People across 6 Projects in the U.S.
Heidi L. Ballard, University of California, Davis
Lina Yamashita, University of California, Davis
Tina Phillips, Cornell Lab of Ornithology
ABSTRACT:
Many claims have been made about impacts of participation in citizen science on science learning. Yet, few studies examine how participation in CS affects participants' perceptions of their roles in, use of, and contributions to science across different CS projects. We applied narrative approach to science identity research and conducted annual semi-structured interviews with 70 participants over 2 years in six CS projects across the U.S. representing three types: contributory, collaborative, and co-created projects. We found many nuanced aspects of science identity across participants. Specifically, participants who spent more time participating in their respective projects were more likely to see themselves as using or doing science, contributing to science, being a part of the scientific community, and using science to effect positive change in community, compared to their counterparts who spent less time. However, even participants who spent relatively little time participating in the projects saw themselves as contributing to science. These findings have implications for the design and implementation of CS programs for ISE, and contribute to our understanding of how participation in scientific activities linked to personally meaningful conservation issues might influence identity, regardless of the number of hours or frequency of participation.

I Like STEM, but am I a STEM-person?"-Effects of Informal Learning and Mentors on STEM Identity
Stephanie B. Wortel-London, Stony Brook University
Angela M. Kelly, Stony Brook University
ABSTRACT:
An afterschool STEM mentoring program was launched as a public-private partnership in a large city in the U.S. with two goals: 1) to provide no-cost, informal science, technology, engineering, and mathematics (STEM) enrichment to underserved middle school students; and 2) to build the teaching and communication skills of a large number of STEM undergraduate students through a clinical service learning opportunity. The qualitative portion of the study evaluated the efficacy of local undergraduates as role models, and how the experience of the year-long program influenced the STEM identity of traditionally underserved middle school participants. As defined by the theoretical framework, STEM Identity is comprised of the sub-constructs of STEM interest, academic self-concept, and the influence of relatable STEM mentors. This paper presents the initial findings of the qualitative portion of the study with respect to outcomes for a sample of eight middle school students participating in the program taught by undergraduate STEM majors from underrepresented backgrounds in the afterschool classroom. A grounded theory approach was used to analyze semi-structured interview transcripts. Preliminary findings from middle school interviews indicate a stronger reported sense of interest, a more engaged STEM academic self-concept, and an appreciation for having access to consistent, relatable mentors.

Identity Development through Practice: Supporting STEM Ecosystems with Internship Experiences in Informal Science Institutions
James F. Kisiel, California State University, Long Beach
ABSTRACT:
There is an increasing effort within the field to develop and support STEM ecosystems as a way to support youth interest and understanding in science and related disciplines. If multiple institutions within a community (both informal and formal education sites) have similar goals of supporting STEM learning, then it would seem that there should also be an opportunity for sharing expertise to create an even stronger array of resources. In an effort to support such an ecosystem, an internship program was established for pre-service teachers at or near the end of their certification program in one of three local informal science education institutions for a 10-week internship, where they engaged in a variety of instructional activities for different audiences (e.g. school groups, families). A mixed methods approach, utilizing surveys as well as interviews (interns and institutional staff), was used to better understand the complexities and perceived outcomes of the internship program. The data suggest that participation in the practices of an informal science educator not only provided ample opportunity to improve engagement, but also contributed to an increased confidence in science instruction, an emerging identity as a reflective practitioner and greater likelihood of self-identifying as a 'science person.'

Understanding How Participation in Middle/High School STEM Clubs Shapes Undergraduate Students' STEM Identities
Hillary Mason, University of Colorado, Denver
Robert M. Talbot, University of Colorado, Denver
Michael Ferrara, University of Colorado, Denver

Bryan Shao-Chang Wee, University of Colorado, Denver
Michael Jacobsen, University of Colorado, Denver
Ronald Rorrer, University of Colorado, Denver

ABSTRACT:

This case study examines the STEM identity of 11 undergraduate students participating in a one-year fellowship working in K-12 STEM Clubs. The focus of this paper is on the meanings undergraduate students' attach to their STEM identities and how these might be shaped by their STEM Club experience. Identity Theory is used as a framework where student views of STEM are reflected in their roles as a (a) STEM student (b) STEM Club participant, and (c) future STEM professional. Autobiographical narratives, monthly reflections, and pre/post semi-structured interviews were analyzed through an interpretivist lens and using iterative, open coding processes. Preliminary findings reveal undergraduate students hold narrow, discipline-focused views of STEM in their role as a STEM student. As STEM Club participants, undergraduate students recognize STEM as more accessible and interdisciplinary as they interact with each other and K-12 students in the fellowship program. Finally, as future STEM professionals, undergraduate students maintain stereotypical views of STEM where only those with certain characteristics can succeed. This study adds to our knowledge about STEM identity, and the implications for informal STEM programming designed to improve undergraduate student learning.

Strand 7: Pre-service Science Teacher Education
Identity and Elementary Preservice Teachers
1:00pm-2:30pm, Hyatt Crockett CD
Presider: Jeni R. Davis, University of South Florida

Exploring the Gap Between Preservice Elementary Teachers' Actual and Designated Identities as Teachers of Science
Martha Canipe, Northern Arizona University
ABSTRACT:
Research on teacher identity has suggested that being able to envision oneself as a teacher of science is an important part of becoming a teacher of science. Elementary teachers are generalists and may not identify themselves as teachers of particular content areas. Using a narrated identity framework, I explored stories told by preservice teachers, mentor teachers, student teaching supervisors, and science methods course instructors about who preservice teachers were as teachers of science. In particular I examined the nature of the gap between who preservice teachers were at the present moment (actual identities) as well as who they expected to be in the future (designated identities). Findings from this study showed that differences between preservice teachers' actual and designated identities influence opportunities to learn about what it means to be a teacher of science. This took different forms with each preservice teacher. These findings suggest that supporting preservice elementary teacher identity development as teachers of science is an important part of preparing them to teach science. Additionally, it is essential to examine identity stories and enactments in concert with each other in order to gain deeper understandings of how identities are developed and put into practice in classrooms.

Preservice Teacher Attitudes Toward Science and Science Teaching Based on Autobiographies
Amity F. Gann, Temple University
Janelle M. Bailey, Temple University
Brian T. Cooper, Temple University
ABSTRACT:
Teachers' attitudes toward the subjects they teach, a factor affecting developmental trajectories and student outcomes, are likely developed long before the teacher enters a classroom. It is therefore useful to examine the experiences that led to these attitudes. We sorted preservice elementary teachers (PSETs) into different profile groups based upon the experiences and emotions they described in science autobiographies. Autobiographies were sorted into profiles that describe how the PSET feels about science and about teaching science in the future. Science teacher educators may find these profiles, which provide broad descriptions of students in their classes, useful to help better address specific needs of PSETs as they prepare to lead students of their own.

Science Teacher Identity as a Lived Experience: A Case Study of Beginning Elementary Teachers
Lucy Avraamidou, University of Groningen, Netherlands
ABSTRACT:
Grounded within Holland's et al., (1998) conceptualization of identity and model of Figured Worlds this case study aimed to respond to the following questions: (a) How do 6 beginning elementary teachers view themselves as science teachers? (b) How have the participants' participation in various figured worlds (family, schooling, university, first-years of teaching) shaped their science identity trajectories? In order to characterize the participants' formation of science identities over time, various data regarding their life histories in relation to science were collected: science auto-biographies, self-portraits, interviews, lesson plans, and classroom observations. The analysis of the data illustrated how the participants' identities have been in formation from their early years of their lives and how various events, experiences and interactions had shaped their identities through time and across contexts. These findings are discussed alongside implications for theory, specifically, identity and life history intersections, for teacher preparation, and for research related to explorations of beginning elementary teachers' identity trajectories. 0 0 1 174 993 PSU 8 2 1165 14.0 Normal 0 false false false EN-US JA X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0in 5.4pt 0in 5.4pt; mso-para-margin:0in; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:12.0pt; font-family:Cambria; mso-ascii-font-family:Cambria; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin;}

Strand 8: In-service Science Teacher Education
Teacher Attitudes, Beliefs, & Empowerment
1:00pm-2:30pm, HBG Convention Center 008A
Presider: Ibrahim H. Yeter, Texas Tech University

The Relationship Between Reform-based Beliefs and Practices for Beginning Science Teachers in an Induction Program

Joshua A. Ellis, Michigan Technological University
Elizabeth A. Ring, University of Minnesota
Julie C. Brown, University of Minnesota
Gillian H. Roehrig, University of Minnesota

ABSTRACT:
In the absence of high quality, science-specific induction support, science teachers' beliefs and classroom practices are consolidated into teacher-centered, didactic practices as they are socialized into the classroom (Authors, 2003; Simmons et al., 1999). This study presents findings from an NSF Noyce research project investigating induction strategies that go beyond addressing retention to positively shape the professional growth of beginning secondary science teachers as reform-based practitioners. An explanatory embedded multiple case study design (Yin, 2013) was used to assess how six science teachers understood and enacted reform-based strategies within their K-12 classrooms. Three cases were defined: teachers whose reformed beliefs increased and reformed practices increased over the span of one academic year; teachers whose reformed beliefs increased and reformed practices decreased; and teachers whose reformed beliefs decreased and reformed practices increased. Results reveal a surprising degree of variation in how new science teachers' beliefs about and enactment of reform-based teaching practices change during their first year of participation in a teacher induction program. Findings illustrate the need for induction programs to attend to the social, emotional, and affective needs of the teachers in conjunction with pedagogical supports.

Exploring Routes into Student Engagement: An Aspect of the Pedagogical Reasoning of Expert Teachers

Stephen Keast, Monash University
Ian J. Mitchell, Monash University
Debra Panizzon, Monash University
J. John Loughran, Monash University
Judie Mitchell, Monash University
Lucy Rutherford, Monash University
Melissa Tham, Monash University

ABSTRACT:
We use data from a 3 year study of the pedagogical reasoning of teachers who were identified as being expert –not just experienced to focus on how these teachers framed and planned for student engagement. Engagement is a multi-faceted construct and with behavioural, affective, cognitive, agentic and metacognitive engagement reflecting different teaching purposes and having different implications for pedagogy. Data was collected from two cohorts of 20 elementary and secondary teachers of science. The teachers worked in pairs and data included tapes of planning conversations, of group interviews and artefacts from cohort meetings. The thinking of these expert teachers about engagement was more complex than what has been reported in other studies. Rather than a deficit discourse focusing on behavioural and affective engagement, these teachers focused on how they could generate cognitive, agentic and metacognitive engagement with thinking that flowed from strong beliefs about stimulating and supporting quality learning. They sought affective engagement, but saw this as no more than an entry point into on-going cognitive engagement. They made no specific plans for behavioural engagement and were confident that this would be a natural outcome of classrooms characterised by quality learning and a sense of shared intellectual control.

Developing a Model of Subject Teaching Competence Based on Interviews with Secondary Science Teachers

Silin Wei, College of Material, Hangzhou Normal University
Qiaoli Wang, Hangzhou Normal University
Yuane Jia, University of Virginia
Pengfei Zhang, Hangzhou Normal University

ABSTRACT:
For secondary teachers, teaching competence of a subject has a great impact on their performance and teaching quality and thereby students' learning outcomes. Understanding of the essential components of teachers' subject teaching competence and their connections could inform subject teacher training and practice. Based on in-depth interviews with 10 distinguished secondary science teachers, the present study employed the Grounded Theory approach to construct a model on subject teaching competencies through the use of MAXQDA12 software. This model proposed six core components for subject teaching competence, i.e., ontological, instrumental, conditional, practical, dispositional, and developmental aspect, respectively. All aspects develop dynamically and interact with each other. The model illustrates several characteristics, subject-oriented, structural, dynamic and developmental. It provides a theoretical framework that offers guidelines on how to train and improve teaching competence of subject teachers and how to measure and evaluate teachers' teaching competence. It is also promising for developing teaching standards of specific subjects.

An Experimental Study of an Urban Museum-based Teacher Professional Development Program's Impact on Student Achievement

Aaron Price, Museum of Science and Industry, Chicago
Ashley Chiu, Museum of Science and Industry, Chicago

ABSTRACT:

We present results of a study of a museum-based science teacher PD program on students. Teachers accepted into the program were randomly placed into a control or treatment group. The control group was given delayed admission to the following year while the treatment group participated in the full program. A total of 159 teachers and 3,342 of their students participated in the study by taking a pre- and post-test bookending the school year in which the PD program took place. Teachers were assessed on domain content knowledge and attitudes towards science teaching. Students were assessed on domain content knowledge and attitudes towards science in general. Domain content questions were taken from standardized state and AP tests, with an open-ended "Explain:" prompt added to a quarter of the items. Results show that student knowledge scores doubled over the control group, a statistically significant difference. There was no change in science attitudes. Teacher scores on the knowledge test also increased more than the control group, but were not statistically significant at the p = .05 level. Teacher's attitudes towards teaching science increased over the control group in areas of self-efficacy, lower anxiety and greater agreement about the importance of teaching science.

Strand 10: Curriculum, Evaluation, and Assessment
Issues in Biology Curriculum and Assessment
1:00pm-2:30pm, HBG Convention Center 006C
Presider: Annemarie Palincsar, University of Michigan

Acceptance and Understanding of Evolutionary Theory in Chilean Middle School Students: A New Instrument
Juan Jimenez, Illinois Institute of Technology
Judith S. Lederman, Illinois Institute of Technology
Norman G. Lederman, Illinois Institute of Technology
Hernan Cofre, Pontificia Universidad Católica de Valparaíso
Claudia Vergara, Alberto Hurtado University
ABSTRACT:
Theory of Evolution is a key concept in science education, and is fundamental to understand biology. At the same time, the theory of evolution is considered an important concept to reach scientific literacy. However, there are few validated instruments that assess the level of acceptance and understanding of theory of evolution for middle and high school students. The aim of the present study is to develop a valid and reliable instrument to assess the Acceptance and Understanding of Evolutionary Theory in Chilean Middle School Students. The instrument is composed by 18-item Likert scale assessing acceptance and 30-item multiple choice questions assessing understanding of evolutionary theory. The instrument was validated with 92 ninth grade students from Santiago, Chile. Test scores were analyzed using SPSS. A final part of the pilot testing process included 45 eighth grade students who answered the questionnaire as a pre and post test. The content validity, face validity, internal validity, construct validity, and reliability are discussed. Results indicate that this new instrument is valid and reliable to assess acceptance and understanding of evolutionary theory in middle school students.

Expert Panel Content Validation of the Secondary-Biology Concept Inventory (S-BCI)
Andria Stammen, The Ohio State University
Deborah Lan, The Ohio State University
Anita Schuchardt, University of Pittsburgh
Lin Ding, Ohio State University
Kathy Lea Malone, Ohio State University
William Boone, Miami University
Zakee Sabree, The Ohio State University
ABSTRACT:
Concept inventories are widely used by researchers and educators as a tool for assessing learner's content knowledge. A wide variety of concept inventories exist across disciplines, however, most of these concept inventories have been validated for tertiary-level students but not secondary-level students. To help fill this gap, our goal is to develop the Secondary Biology Concept Inventory (S-BCI). The purpose of this study is to describe the first step of item development for the Secondary-Biology Concept Inventory (S-BCI). Specifically, this study focuses on how data from a multi-panel expert review was used in the S-BCI item content validation and refinement process. Of the 61 questions reviewed, 14 items were identified as having content validity concerns by the expert panel. Generally, these content validity concerns fell within two categories: (1) a lack of context, and (2) a lack of precise phrasing. Using the data from the multi-panel expert review, the 14 items with content validity concerns were refined and modified before the second phase of the validation process, which included student interviews and questionnaires. The next step in the development of the S-BCI is the psychometric analysis of validity and reliability using the Rasch Partial Credit model.

Development of a Concept Inventory to Measure High School Biology Students Concept Knowledge
Kathy Lea Malone, Ohio State University
Andria Stammen
Lin Ding, Ohio State University

Anita Schuchardt, University of Pittsburgh
William Boone, Miami University
Zakee Sabree, The Ohio State University

ABSTRACT:
The NRC framework for science education and the NGSS have created a need for additional research and development of curricula. However, there is a lack of reliable and valid measurement instruments available for use in biology at the secondary level. The 53 newly developed assessment items targeted the major NGSS standards in biology. The answer stems were designed to target specific alternative conceptions. This paper describes the Rasch analysis of this newly developed biology concept inventory targeting secondary school students. Over a thousand students from several regions of the country took part in the study. The analysis produced an assessment that consists of 25 items entitled the Secondary Biology Concept Inventory (S-BCI).

Investigating Scientific Practices, Crosscutting Concepts, and Core Ideas in Undergraduate Biology Syllabi
Claire M. Morrison, Michigan State University
Sarah E. Jardeleza, Michigan State University and Salisbury University
Rebecca L. Matz, Michigan State University

ABSTRACT:
At a large, research-intensive university (RIU), reform efforts have focused on incorporating three-dimensional learning into introductory biology, chemistry, and physics courses. Three-dimensional learning is the set of scientific practices, crosscutting concepts, and core ideas presented in the National Research Council report, A Framework for K-12 Science Education. To gauge the effects of these efforts, we developed a protocol to evaluate the presence of the three dimensions in syllabi. This protocol focuses on syllabi from introductory RIU biology courses, and can be used to reliably identify evidence for each scientific practice, crosscutting concept, and core idea. Coders categorized each syllabus as having no, weak, or strong evidence for each dimension with an intraclass correlation of 0.75 or higher. After applying this protocol to 108 syllabi over 11 semesters, we found one course that shows a significant increase in evidence for five scientific practices and one crosscutting concept during the four-year span of the reform effort. Two of these practices were significantly more prevalent among instructors who had been involved in the reform efforts. Our initial data suggest that some departmental change has occurred. Future data analysis will correlate the data from the syllabi, class meetings, and exams in each course.

Toward Interdisciplinary Science Learning: Development of an Assessment for Interdisciplinary Understanding of 'Carbon Cycling'
Hye Sun You, Michigan State University
Jill A. Marshall, University of Texas, Austin
Cesar Delgado, North Carolina State University

ABSTRACT:
This study aimed at developing and validating an assessment that measures interdisciplinary understanding for the topic carbon cycling. The impetus for this study is the recognition of assessment as "the 'black hole' of interdisciplinary education" in K-16 science education (Boix Mansilla, 2005, p. 18). This study followed the construct-modeling framework (Wilson, 2005). A final version of the ISA was developed including 11 multiple-choice (MC) items and eight constructed response (CR) items. 454 students (9th grade to college seniors) were administered the assessment through the Qualtrics online environment. For the CR items scoring rubrics were developed and used to code student responses by a group of evaluators. Agreement between coders was greater than 90%, indicating excellent inter-rater reliability. Item Response Theory (IRT) models, a two Parameter Logistic Model and a Generalized Partial Credit Model, provided evidence of the construct validity of the assessment items. All items reflected unidimensional construct and local independency in the IRT analyses. All except one item were a good fit to the models. The 19 items showed modest internal consistency (Cronbach's alpha =0.782). The findings suggest that the ISA is a promising and valid tool to assess interdisciplinary understanding in learning carbon cycling.

Strand 11: Cultural, Social, and Gender Issues
Examining Conditions that Facilitate the Success of All Learners
1:00pm-2:30pm, Hyatt Republic ABC
Presider: Keith R. Langenhoven, University of the Western Cape

Measuring Science Success through One's Advocacy and Mentorship: Examining the Experiences of Black Male PhDs
Shari Watkins, University of Delaware

ABSTRACT:
This critical qualitative study sought to best understand the science success and the impact of racism on the STEM career trajectories of 16 African America men PhD scientists and engineers. The lived experiences of African American men PhD scientists and engineers were examined from the men's perspectives. The use of Critical Race Theory (CRT) as the theoretical framework invited the voices of the participants. Through the use of counter-storytelling, a critical race methodology, the men's stories were documented.

The narratives of the men revealed, measuring one's success through one's advocacy to be an instrumental finding that constituted science success for African American men. The CRT tenet a commitment to a social just STEM was used to discuss the ways the men mitigated the negative impact of racism in their experiences in STEM. The findings of this study highlight the complexities of sustaining as a scientist or engineer for African American men PhDs. Further their narratives serve as "experiential knowledge" to help inform educators, researchers and policy makers about the contributions of African American men scientists and engineers in their STEM communities.

The Effect of Gender Composition on Small Groups in High School Science
Julie R. Robinson, University of Massachusetts, Amherst
Martina Nieswandt, University of Massachusetts Amherst
Elizabeth McEneaney, University of Massachusetts, Amherst
ABSTRACT:
Research indicates that various societal, educational, familial, and identity-related factors affect girls' science motivation disproportionately to boys. Situated in self-determination theory (Ryan and Deci, 2000a, 2000b) and the stereotype inoculation model (Dasgupta, 2011), this qualitative study explores how autonomy, competence, and relatedness are manifested in the behaviors of students working in small groups on an inquiry-based science task, with a focus on how the group's gender composition affects these behaviors. Participants include five small groups of high school students, representing varying gender compositions, from three biology classes in two rural New England schools. Preliminary thematic analysis indicates that autonomous behaviors tend to differ between genders regardless of group composition: girls manifesting autonomy in more task-oriented behaviors and boys exhibiting more exploratory behaviors. Competence and relatedness, in contrast, appear to manifest differently between groups of varying gender composition but not along gender lines. Groups with female majority tend to show more cohesion and collaboration as well as fewer stereotypically gendered behaviors than those with gender dyads. Implications for practitioners are evident: providing opportunities for collaborative group work and attention to gender composition will present greater access for all students to the conditions required for motivation and engagement in science.

Conceptualizing Computing for Urban Latino Youth: A Reciprocal Model for Teaching Computational Competencies
Rouhollah Aghasaleh, Georgia State University
Patrick J. Enderle, Georgia State University
Anton Puvirajah, Georgia State University
Judith Monsaas, University System of Georgia
Suzanna Roman, Georgia State University
Renesha Hendrix, Georgia State University
Ying Zhu, Georgia State University
Conceptualizing Culturally Responsive Climate Literacy in Indigenous Communities
Alaina Szostkowski, University of Minnesota, Twin Cities
Devarati Bhattacharya, University of Nebraska, Lincoln, NE
Gillian Roehrig, University of Minnesota
ABSTRACT:
A Reciprocal Model for Teaching and Learning Computational Competencies (ARMTLCC) is a three-year long project that extends existing research in the field by propositioning a model to teach Computational Competencies (CC). While most CC research with youth has occurred in single platform, shorter duration contexts (Denner, Werner, & Ortiz, 2012; Kafai, Fields, & Searle, 2012; Resnick, et al., 2009; Sherrell, Malasri, Mills, Thomas, & Greer, 2012), ARMTLCC aims to examine youths' CC over four semesters through experiences with multiple platforms and a well-supported curriculum. Like previous research cited above, we aim to lower the floor and widen of the walls of CC focused classrooms, broadening access to computational learning by making it easy for students to take the first step toward programming and allowing for a wide variety of interests, likes, and indulgencies to be accommodated (Papert, 1980; Resnick, et al., 2009). Thus, Relevant, Engaging, and Authentic Learning (REAL) experiences becomes key in education of preservice teachers as well as young urban Latino adolescents. One of the reasons for this is that students in a largely adult dominated culture of schools are often limited in the way they can experience and gain knowledge, with fewer opportunities to talk, discuss, and experience the practices of the STEM community (Authors, 2012). These REAL experiences including "afterschool STEM programs have the potential to reach minority and typically underserved audiences in ways that schools and even museums cannot" (Center for Advancement of Informal Science Education, 2013). These programs, however also need to be designed in ways that are relevant and appropriate for the target audiences (Cox-Petersen, Melber, & Patchen, 2012).

Bridging Theory and Practice: Utilizing Hip-Hop Pedagogical Framework in an Urban Science Classroom ***(Virtual Presentation)***
Edmund S. Adjapong, Columbia University
ABSTRACT:
A significant amount of research regarding Hip-Hop Based Education (HHBE) fails to provide insight on how to incorporate elements of Hip-Hop into daily teaching practices; rather educators focus mainly on incorporating Hip-Hop culture into curricula. This study explores the impact of pedagogical approaches that are directly tied to the creative elements of Hip-Hop in an urban science

classroom. This study provides insight on ways Hip-Hop can be incorporated into the art and science of teaching, extending current HHBE research, which mainly discusses how Hip-Hop can be used to design curricula based on music and rhymes.

Strand 11: Cultural, Social, and Gender Issues
Symposium: Being Human in STEM Contexts: Reading Wynter for Rethinking/Reimagining Equity and Equal Educational Opportunity
1:00pm-2:30pm, Hyatt Travis CD
Presider: Jomo W. Mutegi, Indiana University

Being Human in STEM Contexts: Reading Wynter for Rethinking/Reimagining Equity and Equal Educational Opportunity
Jennifer Adams, Booklyn College, CUNY
Matthew Weinstein, University of Washington
Gillian Bayne, Lehman College
LaToya Strong, CUNY
Jean R. Aguilar-Valdez, Portland State University
Jomo W. Mutegi, Indiana University
ABSTRACT:
This symposium brings together scholars interested in exploring Sylvia Wynter's analysis of the development of the Western colonialist episteme and its productions of categories of race, gender and ethnoclass in the project of desettling, decolonizing and reimagining science education. Drawing on Wynter's notions of Man, humanness and knowledge, the presenters will engage participants in a dialogue around how these have and continue to shape social institutions and hierarchies, including schools and classrooms and science-learning contexts. Using Wynter's conceptions as foundational we plan to have a generative discussion that will lead to collaborations and approaches that challenge existing frameworks and approaches to equity in order create a paradigm shift towards more knowledge inclusive and critically-oriented teaching and learning contexts.

Strand 14: Environmental Education
Preparing Pre-service and In-service Teachers
1:00pm-2:30pm, HBG Convention Center 006A
Presider: Allan Feldman, University of South Florida

Comparing Motives and Environmental Literacy between Incoming Teaching-oriented and Non-teaching-oriented Students in Interdisciplinary Environmental Programs
Iris Alkaher, Kibbutzim College of Education
Daphne Goldman, Beit Berl Academic College
ABSTRACT:
One aspect of the increasing position of sustainability in higher education is establishment of distinct interdisciplinary environment-oriented programs. Based on evolving standards concerning teaching as a complex professional occupation, this study compared the motives and environmental literacy (EL) of undergraduate and graduate incoming students in teaching and non-teaching oriented environmental programs in Israel. For all students acquiring knowledge was the major motive for studies. Undergraduate student-teachers demonstrated the least developed EL, although it is slightly higher than that found for incoming student-teachers a decade ago. Graduate teacher-students displayed strong identity as educational agents-of-change, however, their limited environmental-knowledge raises questions concerning provision of knowledge foundations in undergraduate teacher-training programs, indicating necessity to supplement this in graduate teacher-programs. Graduate non-teaching students perceive these studies as a means for developing an environmental career and enter these programs relatively environmentally-literate. The implications focus on necessary components and characteristics of each type of environment-oriented program. One implication, arising from the positive impact of subjective knowledge on pro-environmental behavior, suggests that environment-oriented studies implementing pedagogies which actively involve students may be more effective in encouraging environmentally-accountable citizenship. The nature and content of active engagement should be aligned to the type of professional development of each program.

Content Knowledge Versus Pedagogical Skills: What Should We Emphasize in Pre-service Sustainability Courses?
Adiv Gal, Kibbutzim College
Dafna Gan, Northeastern University
ABSTRACT:
Instructors have an important role in educating pre-service teachers. Currently, the field is debating whether content knowledge or pedagogical skills is more important especially in education for sustainability (EfS). Is the instructors' perspective enough to predict the self-efficacy of pre-service teachers to promote EfS in their classes? Are there factors that can predict this self-efficacy? How do instructors of EfS courses perceive their role in leading pro-environmental behavior change in pre-service teachers? To answer these

questions, we used the lenses of EfS, self-efficacy theory, and constructivist versus positivist perspectives. In this mixed-methods case study we analyzed questionnaires, interviews, syllabi, curricula, and documents. The findings reflected tension between the positivistic approach (based on scientific knowledge construction) and the constructivist pedagogical approach (based on active learning). Moreover, there is a gap between attitudes and behavior in pre-service teachers. The positive attitudes towards the environment were higher than the willingness to act to improve social and environmental conditions in the private and public spheres. This finding contrasts with the instructors' beliefs that changing attitudes will lead to pro-environmental behaviors. Finally, we found that pedagogical skills were the predictor for self-efficacy to promote EfS.

In the Context of Education for Sustainable Development: Environmental Literacy Level of In-service Classroom Teachers
Aysegul Derman, Gaziantep University
Esme Hacieminoglu, Necmettin Erbakan University
ABSTRACT:
The purpose of this study is to investigate the environmental literacy level of the in-service classroom teachers and the quality of integrating of the environmental education to their lessons. In this descriptive and correlational study 269 in-service classroom teachers in a county in Southeastern Anatolia Region of the country constituted the sample of the study. The environmental literacy scale has been used as the quantitative data collection tool and questionnaire with 6 open ended questions has been used as the qualitative data collection tool. Descriptive statistics results showed that in-service teachers' environmental knowledge level were low, however; attitudes, environmental uses, and environmental concern were respectable level. Results revealed that year of experience had a significant main effect on in-service teachers' environmental knowledge. The qualitative findings have shown that the great majority of the teachers which have participated in the present study are giving place to the environment issues in their education. The classroom teachers are giving place to the environment issues mostly in Social Studies lessons, and also in Turkish, Science and Social Sciences lessons. They have declared that they were being faced with problems about the apathy of the students, the student-induced negativity, the time, the equipment failure, etc.

Pre-service Elementary Teacher Participation and Learning during Clean-up Australia: A Volunteer Environmental Community Event
Wilhelmina Van Rooy, Australian Catholic University
ABSTRACT:
The Australian media makes frequent mention of environmental/sustainability issues, and the need for industries and the community to take responsibility for actions that impact on the Australian landscape. Clean Up Australia (CUA) is the nation's largest, community event where citizens remove trash from local parks/reserves. This study reports on the experiences of pre-service elementary teachers who participated in the 2015 CUA event, their developing knowledge and understanding about the environment and sustainability issues gained from that event, and the ability of a university assessment task to identify and challenge these pre-service teachers' views as consumers of manufactured goods. Pre-service teachers submitted written work as part of the assessment which was then analysed from an interpretive lens. Findings of the analysis indicated that in general pre-service teachers found involvement with CUA to be a worthwhile part of their learning about the impact of trash on the environment and the power of community involvement as a force for good. Normal 0 false false false EN-US JA X-NONE /* Style Definitions */ table.MsoNormalTable {mso-style-name:"Table Normal"; mso-tstyle-rowband-size:0; mso-tstyle-colband-size:0; mso-style-noshow:yes; mso-style-priority:99; mso-style-parent:""; mso-padding-alt:0cm 5.4pt 0cm 5.4pt; mso-para-margin:0cm; mso-para-margin-bottom:.0001pt; mso-pagination:widow-orphan; font-size:12.0pt; font-family:Cambria; mso-ascii-font-family:Cambria; mso-ascii-theme-font:minor-latin; mso-hansi-font-family:Cambria; mso-hansi-theme-font:minor-latin; mso-ansi-language:EN-US;}

Concurrent Session #13
2:45pm – 4:15pm

Strand 1: Science Learning, Understanding and Conceptual Change
Symposium: Constructing a Framework for Understanding Model-Based Teaching and Learning Processes
2:45pm-4:15pm, Hyatt Seguin AB
Presider: Jonathan Shemwell, University of Maine
Discussant: Jim Minstrell, FACET Innovations
Presenters:
John J. Clement, University of Massachusetts
Grant Williams, St. Thomas University
Maria Cecilia Nunez-Oviedo, University of Conception
A. Lynn Stephens, University of Massachusetts
Jim A. Minstrell, FACET Innovations

Jonathan Shemwell, University of Maine
ABSTRACT:
Modeling is one of the major scientific Practices described in the NGSS. The panel will discuss four different aspects of the development of a theoretical framework that begins to unpack sub-practices for Modeling. The first study proposes an initial framework derived from a study of expert scientists as a starting point. The emerging framework has the goal of integrating model-based, heuristic, and imagistic processes. Three studies of classroom transcripts used an iterative process of construct development cycles to identify and describe teaching strategies and corresponding learning processes at the four nested levels of the framework. The levels are not 'stages' but rather levels of sub-processes, from large-grained to fine-grained. The discussion will focus on the teaching strategies identified at each level, with classroom examples, the challenges of casting these strategies in a form useful to teacher educators, the implications for pedagogical theory of scientific modeling, and how these findings relate to other efforts in the field. Facilitated audience discussion should allow for rich interplay of ideas concerning implications of the framework and potential directions for further development. An important goal is to deepen and sharpen pedagogical theory concerning instruction in scientific modeling.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Disciplinary Practices in STEM
2:45pm-4:15pm, HBG Convention Center 007A
Presider: Anat Yarden, Weizmann Institute of Science

Developing Scientific Language through Interactive STEM
Robert M. Capraro, Texas A&M University
Mary Margaret Capraro, Texas A&M University
Niyazi Erdogan, Balikesir University
Sencer Corlu, Bahcesehi University
Tufan Adiguzel, Bahcesehir University
Tugba Oncer, Texas A&M University
ABSTRACT:
Scientific language is a necessary component for STEM success. It can be developed through experiences and attention to the development of STEM activities that are rich in language and can be acquired through practical experiences and systematic practice. Secondary students from Honduras, Italy, Turkey, Canada, Guatemala, Mexico, China, and the United States participated in an informal 2-week STEM summer camp where they learned to use Google Sketchup® and a 3-D printer to "Make" their own object. They interacted with peers and collaborated on issues as they arose to solve problems and master the task. The Aural/Spatial Interactions and Invariant Components of Vocabulary for STEM instrument was used to examine the development scientific language development. The data yielded two models Scientific Language Development and Language Progression models that provide an important glimpse into the importance of how the communication pathways develop and the importance for teachers to be made explicitly aware that helping students to build their scientific language can facilitate STEM learning by mitigating misconceptions and misunderstandings, while facilitating the development of a STEM disciplinary language.

Examination of Chemical Representations in High School Chemistry Textbooks
Betul Demirdogen, Bulent Ecevit University
ABSTRACT:
The purpose of this study was to evaluate the chemical representations that are present in Turkish high school chemistry textbooks. Content analysis was the method of research. Four chemistry textbooks, which were commonly used in Turkey, for each grade, were selected. When evaluating the representations a rubric including five main criteria was used: (1) type of representation, (2) interpretation of representations' surface features, (3) representations' relatedness to text, (4) properties of representations' caption, and (5) degree of correlation between subordinates comprising a multiple representation. The results of the study revealed that the chemical representations used in the textbooks are mainly macroscopic, symbolic, and hybrid. Majority of the representations had explicit surface features and appropriate captions. Moreover, they were completely related to the text. Most of the multiple representations had sufficient links between their subordinates. Recommendations for textbook writers and future research are provided.

Foxes and Rabbits, Fish and Dolphins: Learning and Representing Ecosystem Dynamics with Embodied-interaction Sensing Technologies
Alejandro Andrade, Indiana University
Adam V. Maltese, Indiana University
Joshua a Danish, Indiana University
ABSTRACT:

Reasoning about ecosystems requires a focus on systems dynamics, and students need to make sense of external representations used to describe the properties of these systems. In order to support student learning of ecosystem dynamics and use of graphical representations, we designed an embodied simulation to help students represent predator-prey feedback loops by gesturing with both hands to represent these relationships. We hypothesized that students' graphical representations would be mediated by the inclusion of gestures in the students' explanations during post-tutorial interviews. Fifteen 3rd and 4th graders were interviewed and interacted with the simulation. We found that students were more likely to include complex systems concepts in their post-tutorial explanations. We also found that while students made numerous graphical errors prior to the tutorials, after the embodied interaction a significant proportion of students were able to graphically represent the predator-prey dynamic using line graphs. These results show that elicited gestures can be used to productively support student learning of dynamic systems, particularly when used in conjunction with sensing technologies that support students in connecting their gestures to representations, and in particular in a scientific domain such as complex systems which traditionally has been challenging to students from all grades.

Some Factors that Constrain the Emergence of Epistemic Discourse in Science Classrooms
Ashley H. Murphy, University of Texas, Austin
Sarah Harris, University of Texas, Austin
Victor D. Sampson, University of Texas, Austin
ABSTRACT:
This study examines how the occurrence of epistemic discourse the occurs within groups changes over time as students participate in several different laboratory activities that give them an opportunity to participate in the practices of science. Findings indicate that the amount of choice that students have during laboratory experience is related to the occurrence of epistemic discourse within a group. Student choice appears to be constrained by the structure of the activity and the actions of the teacher.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Structuring Whole Group Interactions
2:45pm-4:15pm, Hyatt Crockett CD
Presider: Noh Heejin, Korea National University of Education

Ambitious Science in the Kindergarten Classroom: Models as Mediators for Talk, Gesture, and Participation
Michelle Salgado, University of Washington
Mark Windschitl, University of Washington
ABSTRACT:
This study focuses on the mediating roles of scientific models in the kindergarten science classroom as students leverage models to learn about complex phenomena, explain their thinking, and become engaged participants in the process and practice of scientific modeling. The first author designed the featured curriculum of this study and served as an instructional coach in the classroom during an eight-week unit on forces and motion. We designed a responsive learning environment with the teacher in order to facilitate participation by all students, including the focal student participants. As kindergarten students engaged in the modeling process three distinct themes emerged related to their work with modeling 1) the modeling process supported collaborative student talk about complex natural phenomena 2) students routinely used a combination of gesture, modeling conventions, and inscriptions to purposefully engage in explanatory talk about science concepts 3) models and other representations facilitated productive student engagement within individual modeling experiences which in turn provided an entry point for students to participate in later whole group conversations in which a public model was being explored. We highlight how student engagement with the modeling process is central to their ability to engage with challenging science phenomena in kindergarten.

Elementary Students' Metacognition in the Collaborative Problem-solving
Qingna Jin, University of Alberta
Mijung Kim, University of Alberta
ABSTRACT:
Metacognition has been identified as critical to the general activities of studying, problem solving, and conceptual understanding etc. In the field of science education, the significance of metacognition has also been recognized. However, there still exist great lack of attention on it, especially metacognition of younger learners and metacognition beyond individual level. In this study, we attempt to understand how elementary students' metacognition develop in their collaborative problem-solving. Descriptive and interpretive case study is employed as a research method. The data were collected over a 3-month period in a fifth-/sixth- grade science classroom in Canada. Data resource included video and audio recordings, interviews with focus groups, and students' journals. To interpret the video and audio recordings, a new coding system was developed. Moreover, interview transcriptions and students' journals were also analyzed. With the analysis of the data, we found that (1) during the collaborative problem-solving, students' metacognition (metacognitive regulation) went beyond individual to social level; (2) students' awareness and appreciation of "group" were helpful to the development of metacognitive regulation; and (3) "difference" was the main impulse towards metacognitive regulation, especially, monitoring.

Structuring Learning Tasks to Promote Whole-class Cooperative Behavior
Joshua Premo, Washington State University
Andy Cavagnetto, Washington State University
Kathleen M. Nitta, Washington State University
ABSTRACT:
Education research has repeatedly shown that student interdependency positively impacts small group learning, but the contribution of this to whole-class cooperation has not been addressed. Interdependency is likely to promote whole-class cooperation through increased mutual benefit. This was tested in three undergraduate classes (n = 45) through structuring science learning activities to promote interdependency in task completion and content. Each class completed six activities followed by a whole-class cooperative task. Student behavior during the cooperative task was coded in ten second intervals for each student during the first ten minutes of each session (n intervals = 5351). Preliminary results suggest that structuring social interactions to emphasize mutual benefit increased student cooperative behavior, while also promoting off-task socialization in limited instances.

Whole Group Sense-making Discussions in Science and Mathematics Classrooms: A Query of the Literature
Shannon Gooden, Florida State University
Kirby Whittington, Florida State University
ABSTRACT:
The purpose of this study is to provide a review of the literature on whole group, teacher-facilitated student-centered discussions, specifically in science and mathematics classroom contexts. The work presented here emerged from a related project focused on supporting teachers' facilitation of wrap-up discussions in science classrooms in order to help students make sense of and socially co-construct knowledge through whole group discussions while connecting these new concepts to the big ideas of science. While there is a wide range of established academic research addressing the importance and utility of whole group discussions in math and science, there is an apparent dearth of literature focused specifically on wrap-up discussions and whole group sense making opportunities for students in math and science. With this in mind, a comprehensive meta-analysis of the literature base is useful to further understand the variations of approach, teacher facilitation instructional moves, and the purposes of such discussions. The work here purports to provide a compelling rationale for placing larger research resources and emphasis on wrap-up discussions and social sense making opportunities for students in math and science classrooms.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Integrating Science and Literacy in the Elementary Classroom
2:45pm-4:15pm, HBG Convention Center 006A
Presider: Justin McFadden, University of Louisville

Emergent "Literacy for Sensemaking in Science" Practices for K-5
LeeAnna C. Hooper, Pennsylvania State University
Carla Zembal-Saul, Pennsylvania State University
ABSTRACT:
This study describes the process of empirically identifying candidate Literacy for Sensemaking in Science (LFSS) practices. The research associated with this study represents the first phase of a larger study that aims to leverage literacy practices for science teaching in grades K-5 and identify candidate LFSS practices that can be implemented and further investigated in research-based professional learning opportunities for elementary teachers. In this first step of leveraging literacy practices for science teaching, we analyzed video of an experienced third grade science teacher to identify potential LFSS candidate practices. Through our analysis we identified three emergent practices: (1) engaging students with multiple science-specific texts, (2) eliciting and using students' ideas through talking, writing and drawing, and (3) tying words to meaning. Our findings also support the idea that teachers must have a deep understanding of science concepts and the practice of science in order to develop opportunities for students to engage in rich science discourse and science practices. Our work is grounded in the assumption that targeting science instruction for literacy and language development is a potential in-road for more meaningful science teaching and learning.

Expanding Science Learning Opportunities for Grade 1-2 Students: Impact on Science and Literacy Achievement Outcomes
Nancy Romance, Florida Atlantic University
Michael R. Vitale, East Carolina University
ABSTRACT:
Recognized as a high priority instructional area by the National Research Council and the standards movement, early learning opportunities in science are feasible to implement because children possess a wide-range of cognitive abilities and everyday experiences necessary for science instruction. Further, they prepare children for future success in science and broaden their academic preparation in other curricular areas. In contrast, the impact of children's lack of background knowledge in science can result in long-ranging negative effects on science and schooling. In addressing this long-standing issue, the study, funded by NSF, and being

reported here, investigated the feasibility and impact of implementing an age-appropriate, standards-based, integrated science and literacy instructional model, Primary Science IDEAS, in grades 1-2. A total of 9 experimental and 11 demographically-comparable control schools in an urban, highly diverse school district in Southeastern Florida participated. The 2-year intervention was implemented school-wide in 120 classrooms. Using 2-Level HLM analyses, results showed that experimental students, compared to demographically similar controls, displayed significantly greater achievement outcomes in science and reading as measured by the Iowa Test of Basic Skills. Implications for curriculum research as well as policy changes that increase time for science at the onset of schooling are discussed.

Science and Literacy Integration in Elementary Classrooms: Student Outcomes as a Function of Instructional Practices
Xavier Fazio, Brock University
Tiffany L. Gallagher, Brock University
ABSTRACT:
Our paper presents findings from a design-based research study focused on an integrated science and literacy instructional intervention involving five grade 5 teachers. The study utilized a mixed-methods research design. Analyzing qualitative data produced instructional profiles documenting teachers' salient views and instructional practices regarding science and literacy integration. Furthermore, outcomes from science content, vocabulary, and comprehension assessments demonstrated that the science and literacy intervention significantly ($p < 0.05$) impacted achievement with most teachers. While integrated approaches were successful in terms of student learning outcomes, our study identified gaps in teachers' pedagogical knowledge. Variation in curriculum enactment highlights the need for differentiated professional learning to address teachers' pedagogical views of integration, as well as science knowledge. Our study promotes further practice and research into integrated science and literacy instruction in elementary classrooms

Using Nonfiction Text embedded in Inquiry-based Science to Improve Teacher Science Content and Student Achievement
Terry Shiverdecker, Ohio State University
Deborah Lan, The Ohio State University
ABSTRACT:
Nonfiction Texts in Inquiry-Based Science Instruction (NFTI Science) is quasi-experimental research designed to determine the impact of the NFTI Science professional development program on Grades 3 - 5 teachers science content knowledge and on student achievement. This study seeks to explore the following research questions: Does participation in the NFTI Science professional development program improve teachers' content knowledge of standards-based science concepts? Does participation in their teachers' lessons increase students' achievement of content knowledge of standards-based science concepts? A pre/post test design with a control group is being used to evaluate the effectiveness of the program. Project participants are grades 3 – 5 teachers. The teacher pre/post survey, designed by the research team, was administered at the beginning of the program and again at the end of Year 1. Pre/post content knowledge surveys developed by the research team were used for the participating students in grades 3 – 5. To determine if student gains were a result of the teacher professional development program, a control group of teachers and students was recruited from participating or similar districts. The control group was composed of teachers who did not participate in the NFTI Science program. Early results indicate significant gains in teacher and student science content knowledge.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Related Paper Set: Supporting Model-based Pedagogy in the Secondary Classroom: Stories of Teacher Learning and Enactment
2:45pm-4:15pm, HBG Convention Center 007B
ABSTRACT:
Our research team has worked alongside a team of teachers to develop, implement and refine a year-long sequence of high school biology that is aligned to the NGSS DCIs, CCCs and SEPs. Our sequence is designed around the core practice of modeling. In academic year 2015-16 8 teachers implemented the sequence in their classrooms. Prior to implementation they participated in 8 days of professional development and throughout the year they interacted regularly and were observed by our research team and came together for monthly afterschool meetings. The four papers in this set will present findings from the research we conducted in this setting. Broadly the papers address the question: What did teachers learn about modeling and how to support model-based reasoning in the classroom and what were the consequences of that learning for different aspects of enactment (framing tasks, use of a specific feature curricular feature, and guiding students to build generalizable knowledge)? Each of the papers will take up one part of this question. As a collection we believe they offer insights into how teachers learn about and take up new pedagogical approaches which is particularly salient as our field continues to undertake the work of reforming science education.

Teachers' Understanding of Modeling and Model-based Reasoning in High School Biology
Julia Govea, Tufts University
Candice R. Guy, University of California, Davis

"Model-based Reasoning is Not a Simple Thing": Investigating Teachers' Enactment of a Model-based Curriculum
Candice R. Guy, University of California, Davis

Cynthia Passmore, University of California, Davis

Framing for Sense-making in the Modeling Classroom
Alexandra Tobler, University of California, Davis
Emily Harris, University of California, Davis
Julia Gouvea, Tufts University

Positioning Students as Generators of Science Knowledge: Moving from the Specific to a General Account of Phenomena
Cynthia Passmore, University of California, Davis
Chris D. Griesemer, University of California, Davis

Strand 5: College Science Teaching and Learning (Grades 13-20)
Biology Learning and Assessment
2:45pm-4:15pm, HBG Convention Center 007C
Presider: Lynnsay Marsan, University of Texas

A Mixed Method Exploration of Evolution Acceptance Profiles as Delineated by the Measure of Acceptance of the Theory of Evolution (MATE)
Emily M. Walter, California State University, Fresno
Ephiram Bosse, California State University, Fresno
William L. Romine, Wright State University
ABSTRACT:
Although 98% of AAAS scientists agree that humans and other living things have evolved over time, only two-thirds (65%) of the American public agrees (Pew Research Center, 2015). Recent work (Authors, in press) has explored the Measure of Acceptance of the Theory of Evolution (MATE; Rutledge & Warden, 1999; Rutledge & Sadler, 2007) as a measure of evolution acceptance using modern IRT and Rasch analysis. This work documents that the MATE measures two distinct forms of acceptance – (a) acceptance of evolution facts and data and (b) acceptance of the credibility of evolution and rejection of non-scientific ideas. In this study, we explore MATE acceptance profiles using k-means cluster analysis and explore qualitative and quantitative differences among these profiles from a large diverse population of undergraduate students from the western U.S. (N=1045). Our results support the same five acceptance profiles as our sample from the Midwest: students with (1) uniform high acceptance, (2) uniform moderate acceptance, (3) neutral acceptance, (4) acceptance of facts, but rejection of credibility, and (5) rejection of both facts and credibility. Our paper qualitatively and quantitatively explores these nature of MATE acceptance profiles and considers theoretical implications about the nature of evolution acceptance based on these findings.

Assessing Assessments: Does Success Equal Understanding?
Brian Sato, University of California, Irvine
Cynthia Hill, Tufts University
ABSTRACT:
Grades in STEM courses are distributed under the assumption that high-performing students have mastered the course objectives. Additionally, the science education literature often presents understanding as synonymous with exam performance. Despite these assumptions, we have little knowledge of student thinking about tested phenomena that accompanies scores. To investigate this relationship, we performed a series of written and verbal exercises. Twenty-two students were presented with exam questions and were instructed to include their train of thought in writing, as they approached each question, along with an exam-like response. Some students then participated in a think-aloud interview. We coded the exam-like responses, using an instructor-generated rubric, to award a score. Using this score as a baseline, we read the entirety of the students' writing for their thinking. We found that in 25% of cases, there was a discrepancy between student score and thinking about the material. These results highlight a potential need to re-evaluate our course assessments and to question what understanding those assessments value. Additionally, our work highlights the use of exams as vehicles to enhance student thinking as students' reflection and engagement with their answer choices may offer support for their thinking.

Does Evolution Acceptance Differ across Biological Scales? A Rasch Analysis of the I-SEA
Gena Sbeglia, Stony Brook University
Ross H. Nehm, Stony Brook University
ABSTRACT:
Evolutionary theory is central to biological literacy but has been shown to be widely misunderstood. One reason that has been advanced for this challenging situation is that acceptance of evolution may play a significant role in learning about evolution. Consequently, biology educators have attempted to define the construct of evolution acceptance and empirically measure it using survey instruments such as the MATE (Rutledge and Warden 1999). The MATE was criticized by Nadelson and Southerland (2012)

for not carefully separating the measurement of student acceptance of microevolution, macroevolution, and human evolution. Consequently, they developed a 24-item, likert-scale instrument know as the Inventory of Student Evolution Acceptance (I-SEA), which assesses acceptance of evolution on three subscales: microevolution, macroevolution, and human evolution. Although a large body of psychometric evidence was used to support the validity of the I-SEA, all of the evidence relied on parametric tests of raw data; no tests confirmed that the Likert items were linear or were expressed on an equal-interval scale prior to the psychometric analyses. Our study performs a Rasch analysis of a large sample of I-SEA scores in order to reexamine psychometric validity and test whether scores support claims that student acceptance differs across biological scales.

Instructional Practices of Evolution Instructors at Christian Universities
Sara E. Brownell, Arizona State University
Elizabeth Barnes, Arizona State University
ABSTRACT:
While current research illustrates that addressing students' religious beliefs when teaching evolution can be important for student acceptance of evolution, past research suggests that biology instructors at public colleges are often uncomfortable talking about religion and evolution with their students. However, we hypothesized that the unique religious identities and beliefs of instructors at Christian universities who teach evolution, lead to instructional practices that are different from those reported by instructors at public colleges. We interviewed 32 instructors teaching evolution at Christian universities about their practices teaching evolution and discussing religion and evolution with their students. Through grounded theory and content analysis of the interview transcripts, we found that these instructors overwhelmingly reported using the instructional practices of discussing religion and evolution that have been shown to increase student acceptance of evolution. Further, we found that these instructors reported a high emphasis on affective components of evolution education, by stressing the importance of creating a safe classroom environment for all students of varying beliefs in order to encourage change in student attitudes towards evolution. This data is a step towards illuminating how instructors at public colleges can implement these practices in their courses, which can increase student acceptance of evolution.

Strand 6: Science Learning in Informal Contexts
Family Learning in Informal Settings
2:45pm-4:15pm, HBG Convention Center 006B
Presider: Nancy L. Staus, Oregon State University

Science Antagonist Identity in Everyday Family Engagement
Dana Vedder-Weiss, Ben-Gurion University of the Negev
Aliza Segal, Ben-Gurion University of the Negev
ABSTRACT:
Research on science identity mostly demonstrates how informal learning environments afford the construction of science identity, but rarely attend to the ways informal environments can also lead to alienation from science. Through a socio-cultural framework, which highlights the temporary interactional positions and roles participants play or are assumed to be playing, we explore how antagonist science identity emerges in family everyday interaction. Using data obtained through self-ethnography, we focus on one family's science engagement, investigating why two children in the same family differ in patterns of science participation. By methods pf linguistic ethnography, we zoom in on the moment-by-moment interaction, in order to explore how positioning and roles may help elucidate such local variation. The analysis demonstrates the way routine identification through repeating interactions within the family creates a science identity trajectory of "science antagonist". It suggests considering informal science learning environments not only as affording the construction of positive science identities but also as leading to alienation from science. While research has attended to such issues mostly in school contexts, it's time to start addressing them in informal contexts, in which people may more easily try out various roles in varied communities of practice.

Learning as a Continuous Experience: A Case Study of a Family Learning about Salmon
Suzanne Perin, University of Alaska Fairbanks
ABSTRACT:
Informal science education as a field tends to focus on single sites of sense-making, while families do not take such a narrow approach to their leisure activities. The research question I purse in this paper investigates an ecological perspective on the many experiences of learning science: What are the connections families make across settings and over time, in a way that makes experience continuous? This paper presents a case study of one family who participated in a design-based research study that took place in a natural history museum, aquarium, and along a creek when salmon were spawning. Their shared experiences around salmon provide evidence of how experience is marked as both a momentary, vibrant event full of emotion and cognitive attributes, and is created through many events that draw on arrangements of place, actions, and social positions over time. Tracing how families make use of resources and foster connections across the various learning opportunities available to them in their communities has implications for science education researchers in the challenges of capturing those moments in research, and for educators designing to foster continuous and connected learning.

Pointing-based Joint Observation Strategies used Among Families with an e-Trailguide to Support Sense Making Outside
Lucy R. McClain, Pennsylvania State University
ABSTRACT:
This paper deeply analyzes the role of pointing as an important mode of engagement with nature when a mobile-based learning tool—an e-Trailguide—is used by families during nature hikes. With sociocultural learning theory and the associated concepts of sense making and engagement comprising the foundation of this study, the interactions of 31 family groups as they used an e-Trailguide on a nature trail were analyzed in order to determine how one form of engagement with nature—pointing—supported science-related sense making in the outdoors. Using microethnography and video-based methods for collecting and analyzing data, a thematic analysis focusing on the families' dialogue and gestures at one area of the nature trail resulted in the emergence of a new six-pronged framework to understand families' joint observations of the natural world. These six distinct sense-making patterns related to family pointing-based joint observations were a) device-prompted claim, b) conceptual knowledge claim, c) orienting, d) seeking verification, e) confirmation, and f) inquiry. This newly developed framework provides a necessary addition to the field of informal science learning and family learning because it is an analytical tool that research can use to understand learning with mobile computers in the outdoors.

Strand 7: Pre-service Science Teacher Education
The Growth and Support of Preservice Teachers
2:45pm-4:15pm, Hyatt Crockett AB
Presider: Julianne A. Wenner, Boise State University

"All Jumbled Up:" Agency, Emotions, and Climate Change
Elizabeth Hufnagel, University of Maine
Asli Sezen-Barrie, Towson University
Katherine Pontbriand, University of Maine
ABSTRACT:
Research on the ways in which pre-service teachers perceive their agency in climate change is an understudied area. We drew from the fields of climate change communication and work within science education on agency to illustrate how we conceptualized the pre-service elementary teachers (PSETs) in the study as both learners and teachers. Semi-structured interviews were conducted with nine PSETs at the beginning and end of a semester-long science course on climate change to learn how they perceived of their agency in climate change. In doing so, we attended to their emotional expressions as emotions are indicative of what one cares most deeply about. Using open, iterative coding, the interviews were analyzed for agency and emotional expressions. Two tensions within the PSETs' perceptions of agency emerged from our analysis. A temporal tension was evidenced as PSETs prioritized their agency in the future as teachers, rather than as college students or citizens. Also, the PSETs grappled with individual-collective tensions within their perceptions of their own agency. These findings provide a nuanced view of how the PSETs made sense of their agency with implications for both research and practice.

Challenging the 'Formal' and 'Informal' Divide Through an Ecological Approach to Science Teaching and Learning
Daniel Birmingham, Colorado State University
Lara Smetana, Loyola University Chicago
ABSTRACT:
Greater recognition has been given to informal science learning opportunities and the possibilities it holds to potentially impact formal science learning environments (HFRP, 2009). A National Research Council (NRC, 2015) report suggests that informal science learning environments achieve success because they are designed to align with an ecological perspective of learning (Bronfenbrenner, 1977), where learning is understood as a dynamic, multifaceted process influenced by varied contexts, cultures and interactions. Despite this success, there is little evidence that understandings from informal science learning experiences have informed teaching and learning practices in K-12 science classrooms (NRC, 2009). In this paper, we investigate our efforts to incorporate an ecological approach to learning in our elementary teacher education program through the intentional integration of informal contexts. We argue by experiencing science learning and doing across multiple contexts and having opportunities to activate their multiple ecologies of learning, TCs were able to expand notions of science beyond traditional classroom experiences into seeing science as consequential, dynamic and participatory. Furthermore, this approach led TCs to identify elements of these experiences that they desired to bring into their future classrooms in order to value and activate their future students' learning ecologies.

Promoting Character and Values for Global Citizens: A Socioscientific Issues Framework
Ozgul Yilmaz-Tuzun, Middle East Technical University
Dilek Karisan, Adnan Menderes University
ABSTRACT:

In this study character and values as global citizens assessment (CVGCA) questionnaire was translated and adapted into Turkish. A total of 241 junior and senior pre-service science teachers enrolled in the Department of Elementary Science Education of three different universities constituted the sample of the study. The CVGCA questionnaire was originally developed by Lee et al., (2013) and consists of three phases, namely ecological worldview, social and moral compassion and socioscientific accountability, and included totally 20 items. The scale translation and adaptation were conducted in three phases: scale translation, language identification (with statistical application), and adaptation. Confirmatory factor analysis (CFA) did not support the factor model proposed by Lee at al., (2013). Thus exploratory factor analysis (EFA) was conducted to find out factor structure of the CVGCA questionnaire in Turkish context and resulted in four factor structures: sustainable development, empathetic concerns, moral and ethical sensitivity, and willingness to act. Following CFA analysis confirmed the four factor structure found in EFA analysis.

Teachers to Teachers: Cultural-historical Analysis of Feedback from Experts to Novices
Asli Sezen-Barrie, Towson University
Gili Marbach-Ad, University of Maryland
ABSTRACT:
This paper aims to look at the ways experienced teachers can support preservice teachers' learning to teach climate science. Drawn from the socio-cultural theories of learning, this study uses Engestroms' third generation of cultural-historical activity theory (CHAT) to describe the sociocultural dimensions of communities and their impacts on experienced teachers' feedback. We used a multiple case study approach in which we collected multiple lines of data: a) videos of experienced teachers' verbal feedback during preservice teachers' presentations of climate change lessons, b) experienced teachers written feedback provided after the presentations and c) field notes by the researchers. The analysis of the data included preparation of transcripts and using abductive analysis informed by CHAT to create and iteratively revise codes and subcodes. The preliminary findings show that all aspects of CHAT (subjects, tools, division of labor, norms, community, objects) were apparent in experienced teachers' feedback. However, there was more emphasis on the educational and socioscientific norms in their feedback. Therefore, we suggest more attention to the norms factor in preservice teacher education programs and professional development activities designed for novice teachers when we want the reformist ideas to be implemented in science classrooms.

Strand 7: Pre-service Science Teacher Education
Engineering and Preservice Teacher Learning
2:45pm-4:15pm, Hyatt Presidio ABC
Presider: Michelle Forsythe, Texas State University

Factors Associated with the Functionality of Triads in an Alternative Student Teaching Placement
Christopher Spinler, Iowa State University
Jacob Pleasants, Iowa State University
Joanne K. Olson, Iowa State University
Joleen Henning, Northview Middle School
ABSTRACT:
Triads of cooperating teachers, student teachers, and engineering graduate students worked together to teach engineering and science lessons in elementary classrooms. Over the course of two 16 week semesters, 10 engineering graduate students, 20 cooperating teachers, and 20 student teachers participated in the study. This study reports the level of functionality reached by each triad during a 16 week student teaching placement. Functionality in the context of this study characterizes the degree to which triads were able to efficiently plan and teach lessons while utilizing the expertise of all group members. Data collected from participant interviews, survey instruments, and field notes were analyzed to designate four levels of triad functionality: Highly Functional, Functional, Minimally Functional, and Dysfunctional. Findings indicate four factors associated with triad functionality: presence or absence of group conflict, perceived distribution of group responsibility, extenuating external circumstances, and sharing of group expertise. This research has implications for those working in the areas of engineering education and elementary teacher preparation.

Investigating Teachers' Developing Knowledge of Engineering during a STEM Professional Development Experience
Jacob B. Pleasants, Iowa State University
Joanne K. Olson, Iowa State University
Christopher Spinler, Iowa State University
ABSTRACT:
With the introduction of the NGSS, elementary teachers are now tasked with incorporating engineering into their classroom instruction. This is challenging for elementary teachers, who rarely have a background in engineering content. Because teachers cannot teach what they do not know, working to develop teachers' engineering content knowledge is essential in supporting elementary engineering education. This study reports on a pre-service and in-service elementary teacher education project centered on engineering education. Student teachers and their cooperating teachers were teamed with engineering graduate students in order to support the implementation of engineering lessons in the classroom. One desired outcome of the project was to develop participants'

understanding of the field of engineering. Participants' conceptions of engineers and engineering were assessed as a pretest and posttest, and were also compared to a control group of paired student teachers and cooperating teachers. Participants were assessed using two survey instruments along with an interview, and results were triangulated across all three data sources. Our results show a reduction in misconception views of engineering among participants. They also show that participants view engineers as problem-solvers, but some struggle to place appropriate boundaries on the types of problems engineers solve.

Pre-service Teachers' Perceptions of Engineering and Familiarity with Teaching Design, Engineering, and Technology
Laura K. Ochs, University of Virginia
Frackson Mumba, University of Virginia
Jennifer Chiu, University of Virginia
ABSTRACT:
Increasing the number of K-12 students pursuing STEM related careers has become a prominent goal in science education. Previous research has shown that teachers' perceptions play a role in student career choices. As such, it is important to understand pre-service teachers' perceptions towards engineering. In this study, thirteen secondary science pre-service teachers responded to a survey developed by Yaşar et al. (2006). The survey has four constructs; importance of DET, familiarity with DET, stereotypical characteristics of engineers, and characteristics of engineering and technology. Participants completed the survey before and after instruction on engineering design and how to integrate engineering design in science teaching. Results show that pre-service teachers had positive perceptions of all the four constructs before and after instruction. However, only the familiarity with DET factor exhibited a statistically significant difference between the pre and post-surveys. The results suggest that this group of pre-service teachers held positive perceptions of engineering, even before they received instruction and maintained it throughout the intervention.

Promoting Computational Thinking in Elementary Preservice Science Teacher Education
Zoubeida R. Dagher, University of Delaware
Chrystalla Mouza, University of Delaware
Lori Pollock, University of Delaware
ABSTRACT:
This study reports on an intervention in a preservice elementary teacher education program that aimed to support the development of teacher candidates' understanding of computational thinking (CT), a general education goal at the university and an important science and engineering practice in the Next Generation Science Standards. The intervention involved developing coordinated activities between two required courses in educational technology and science education. The instructors developed synergistic, but independent, activities except for one class session at the end of the semester. Analysis of data obtained from group-generated science lesson outlines illustrate how different groups of teacher candidates engaged in the task of science lesson modification/ enrichment. The findings discuss the relationship between the frequency and quality of CT concepts and underscore the importance of researching scaffolds that support preservice teachers' integration of a variety of CT concepts that drive deeper inquiries.

Strand 8: In-service Science Teacher Education
STEM Teaching & Learning
2:45pm-4:15pm, HBG Convention Center 008A
Presider: Erin E. Peters-Burton, George Mason University

Defining STEM in a Rural School District: A Co-constructed and Co-evolving Process
Debbie Siegel, Oregon State University, Cascades
Michael Giamellaro, Oregon State University, Cascades
ABSTRACT:
A rural school district, in partnership with a local university, has been shifting towards STEM education. This STEM Lab School takes advantage of their local rural contexts and community partners, enhancing student STEM learning and engagement. Defining STEM in this district has been an evolving process. The vision of the "why" of STEM has remained steady, but the "what" has continually been defined and redefined. In this paper, we discuss the dynamic change process during the launch year of the initiative. We focus on the evolving definition of the STEM initiative and the active role individual practitioners played in co-constructing its definition over time for themselves and for the as district as a whole as they worked toward becoming and identifying as a STEM Lab School.

Realizing the Vision: Evidence for STEM Teacher Leadership Identity Development
Dawn Nachtigall, Stony Brook University
Brett Criswell, University of Kentucky
Sam Staggs, University of Kentucky
Greg Rushton, Stony Brook University
ABSTRACT:

Since 2010, our NSF-funded STEM Master Teacher project has had the mission of supporting sixteen physics and chemistry teachers from high-needs schools in becoming teacher leaders. STEM teachers with no prior leadership experience, participated in ~100 hours of professional development designed around a framework previously described by the authors (Authors, 2015, 2016). In this study, we analyzed coded transcriptions of professional development sessions and focus group materials to determine the extent by which Master Teaching Fellows (MTFs) have internalized our conceptual framework. To further demonstrate the internalization of the framework, we endeavored to connect the MTFs discourse with leadership roles they pursue within the program and in the educational community. The analysis indicated that the leadership identities and roles of the MTFs have changed throughout the five years of this project. The MTFs not only internalized the key constructs of the model, they have begun to externalize this leadership identity as teacher leaders in their schools, counties and at professional conferences. By showing how the MTF's leadership identity has evolved allowing them to actively pursue leadership opportunities, we provide insight on how to develop a professional development program to create STEM teacher leaders.

Understanding Conceptual Effects: How Teachers' Conceptual Models of Integrated STEM Education Influence Curriculum Writing
Elizabeth A. Ring, University of Minnesota
Emily A. Dare, Michigan Technological University
Gillian H. Roehrig, University of Minnesota
Preethi Titu, University of Minnesota
Elizabeth A. Crotty, University of Minnesota
ABSTRACT:
National reform documents (National Research Council, 2012; NGSS Lead States, 2013) call for the development of integrated science, technology, engineering, and mathematics (STEM) curricula in an effort to increase the number of students involved in STEM-related coursework and to increase the competitiveness of the United States in STEM-related fields. In order to develop these curricula, however, there is a need to understand teachers' conceptions of integrated STEM and how those conceptions influence curriculum development. This study, contextualized in a professional development (PD) experience, addresses this issue by exploring what components of STEM education K-12 science teachers find fundamental to integrating STEM in the classroom and how these conceptions influence curriculum development. Photo elicitation interviews (PEIs) were conducted with in-service science teachers to understand self-created models of what STEM integration is in order to have a better understanding of how practitioners might use their models in their curriculum and instruction. Additionally, curricula created by teams of teachers in the PD were analyzed to understand how these models were realized in practice. Implications for this work include important considerations for district administrators and other school personnel responsible for developing and implementing integrated STEM curricula in their schools.

Creating STEM Continua: A Phenomenographic Approach to Understanding Perceptions of STEM Integration Models
Emily A. Dare, Michigan Technological University
Elizabeth A. Ring, University of Minnesota
Gillian Roehrig, University of Minnesota
ABSTRACT:
As more and more science teachers are now expected to bring STEM to their classrooms, it is important to understand how teachers understand what STEM is. Understanding that not all representations of STEM are equal, this study used a phenomenographic approach to examine science teachers' perceptions of eight different models of STEM integration. Additionally, this study asked teachers to rank these different models in a continuum in order to understand what models of STEM are accepted or rejected by teachers. Findings reveal that teachers are most attracted to a model of STEM that shows places of overlap between the disciplines represented in the acronym, but that also allows for non-intersecting sections. Teachers were also optimistic about a model that explicitly addresses the connection between school and the real world. This study sheds light on how different models of STEM are perceived by teachers, which can play a role in educating both pre- and in-service teachers about STEM.

Strand 8: In-service Science Teacher Education
Elementary & Middle Grades Teacher Development
2:45pm-4:15pm, Hyatt Republic ABC
Presider: Danielle K. Ross, Northern Arizona University

Enhancing Professional Practice in Primary Science, Technology, Engineering and Mathematics (STEM): An Activity Theory Analysis
Karen Goodnough, Memorial University
ABSTRACT:
In this study, Cultural Historical Activity Theory (CHAT) was adopted as a framework to describe and understand the professional learning of three primary educators who completed three cycles of action research. CHAT was used as a framework to guide data collection and analysis. A contructivist research paradigm was adopted to develop insight into the professional growth of the teachers. Using the components of the basic unit of analysis in CHAT (subject, object, tools, community, division of labour, and norms), the

author describes the changing activity system of the teachers and how this contributed to their professional learning. Contradictions also became a source of professional change for the teachers.

Teachers' Successes and Challenges in Designing and Implementing Middle School Project-based Investigations on Watersheds
Rebecca McNall Krall, University of Kentucky
Justin LeVaughn, University of Kentucky
Bharath Simpath Kumar, Unveristy of Kentucky
Jennifer A. Wilhelm, University of Kentucky
Carol Hanley, University of Kentucky
ABSTRACT:
Project-based learning environments naturally incorporate student-centered investigations and cultivate science and engineering practices through rich learning experiences as presented in the Next Generation Science Standards (NGSS for Lead States). Creating PBL units can be labor intensive, particularly for teachers unfamiliar with this strategy. This case study explored how six teachers participating in a two-year teacher institute designed and implemented project-based units investigating water quality in their local watersheds. Pre and post assessments and surveys were used to identify changes in teachers' content knowledge and understanding of project-based environments. Interviews, field notes, unit plans and artifacts composed the data corpus. Descriptive statistics were used to identify areas of changes in teachers' knowledge of watersheds and project-based environments for the entire sample of teachers in the program. Comparative analysis (Glaser & Strauss, 1967) was used to analyze qualitative data from the six case study participants. Finding illustrate how teachers incorporated essential components of PBL, while facing common challenges of time, curricular demands, and inference from school administrators as they implemented their units.

The Role of the Principal in In-service Teacher Elementary STEM Professional Development
Carolyn A. Parker, The John Hopkins University
ABSTRACT:
This study presents eight principals' vision and enactment of science technology, engineering, and mathematics (STEM) education in eight schools participating in the Johns Hopkins University's STEM Achievement in Baltimore Elementary Schools (SABES) program. A situative framework guided by Desimone's (2009) Critical Features of Professional Development was used to analyze survey and interview data from eight principals of SABES schools. Our analysis demonstrates that while all principals in the study have well-articulated of STEM education that includes professional development for inservice teachers, the principals are lacking resources to adequately support STEM, mainly attributed to the greater district priority of reading and mathematics. Overall, the analysis presented in this paper provides meaningful insights about how STEM education and, more specifically, professional development is enacted at the school-level in eight STEM-focused, urban elementary schools. 96 Normal 0 false false false EN-US JA X-NONE

Strand 10: Curriculum, Evaluation, and Assessment
Crosscutting Concepts and Science and Engineering Practices in Curriculum and Assessment
2:45pm-4:15pm, HBG Convention Center 006C
Presider: Julie Bokor, University of Florida

Developing Assessments for Obtaining, Evaluating, and Communicating Information: Implications for Future assessment Development and Instruction
Jill A. Wertheim, Stanford University
Paolo C. Martin, Stanford University
Jonathan Francis Osborne, Stanford Graduate School of Education
ABSTRACT:
Development of assessments for the Next Generation Science Standards (NGSS) depends on a research base that describes the critical components of each practice and how students' competency progresses in sophistication. One of the practices, Obtaining, Evaluating, and Communicating Information has a limited research base in science, but researchers can take advantage of its close relationship with other disciplines, such as English/Language Arts (ELA). This existing research guided development of a performance task for a 5th grade NGSS performance expectation that probes poorly understood components of this practice. Results of a pre-pilot test using this task with nearly 200 5th and 7th grade students showed that most of the students were able to obtain and combine information from scientific resources such as tables (98%) and diagrams (95%), but few of the 5th grade students could combine the information with their disciplinary knowledge to reason about a phenomenon (33%), or to frame the information to communicate to a specific audience (17%). Study results and feedback from teachers highlight a need for instructional supports that target specific components of the practice and the ways that teachers can take advantage of the cross-disciplinary nature of this practice to support student learning.

Development of an Assessment Measuring Basic Competency in Scientific Data Interpretation and Argumentation
Josephine Louie, Education Development Center
Craig Hoyle, Education Development Center
ABSTRACT:

In a world where science, industry, and all spheres of life are permeated with growing amounts of data, there is an urgent need to promote scientists and a workforce that are skilled in working with data. As educational efforts rise to meet this demand, the core competencies that are critical for working with data remain unsettled, and the field lacks tools that can measure the degree to which such educational efforts are successful. This paper describes the development of a basic scientific data competencies assessment for Ocean Tracks College Edition (OT-CE), a project designed to promote competencies in working with large scientific data sets among undergraduate students in the marine sciences. The 21-item assessment was designed to measure a specific set of data competencies that align with the curriculum goals of OT-CE, and potentially to serve as a tool that may be of use more broadly. Under tight development constraints, we created a scale composed of released multiple-choice items from other established science assessments. This paper discusses the skills we believe the instrument is able to measure along with its psychometric properties, with implications for how this tool can be developed further to be useful for other researchers.

Student Use of Crosscutting Concepts as Tools to Construct Three-Dimensional Science Understanding
Yi Li, Columbia University
Gary Weiser, Teachers College
Min Jung Lee, Columbia University
Ann E. Rivet, Columbia University
ABSTRACT:
A Framework for K-12 Science Education (NRC, 2012) describes learning as engagement in activities in which students develop more sophisticated science understandings through the interplay of the three dimensions: Disciplinary Core Ideas (DCIs), Science and Engineering Practices (SEPs) and Crosscutting Concepts (CCCs). These three dimensions provide useful frames for the science education community to support student learning, but many – especially in the realm of assessment design – still have questions and concerns regarding what three-dimensional science understanding looks like. This proposal outlines some of the findings from a study of responses to assessment tasks that we analyzed in terms of how students use CCCs as tools to leverage existing DCIs to explain natural phenomenon in earth science, biology and chemistry. We describe the similarities and differences among the strongest explanations provided by students in terms of how they use CCCs both as their own dimension and in interplay with their disciplinary core ideas. Finally, we discuss implications and suggestions for three-dimensional assessment.

Students' Use of Crosscutting Concepts in Explanations of Natural Phenomenon
Ann E. Rivet, Columbia University
Xiaoxin Lyu, Columbia University
Diego Rojas-Perilla, Columbia University
ABSTRACT:
Crosscutting concepts (CCCs) are key to three-dimensional science learning, yet the field lacks robust descriptions of what students' CCC understanding looks like and how it relates to disciplinary core ideas (DCIs) and science and engineering practices (SEPs). We developed assessment tasks to explore how students use CCCs to construct scientific explanations. 35 high school students explained the relationship between CO2 fluctuations and global average temperature from three different CCC perspectives: Patterns, Systems and Cause and Effect. Using an iterative coding process focusing holistically on the productive interplay between the dimensions, we identified four categories of student responses. We found that explanations from the three different CCC perspectives a) provided emergent information about students' DCI understandings that would not have been visible if only one explanation was provided; b) gave evidence that students were not able to provide full explanations of the phenomena without appropriately demonstrating understanding of each of the CCCs; and c) students' incomplete or inaccurate explanations still provided useful information regarding the nature of scientific understanding in each dimension. This work provides a useful model for the development and analysis of assessment tasks for three-dimensional understanding as called for in the NGSS.

Role Selection as a Framework for Examining Evidence of CCC Understanding in Student Work
Gary Weiser, Teachers College, Columbia University
Xiaoxin Lyu, Columbia University
Diego Rojas-Perilla, Columbia University
Ann Rivet, Columbia University
ABSTRACT:
In response to the latest reform in science education that calls for a three-dimensional understanding and the important role of crosscutting concepts within it, we developed assessments aligned with this new way of thinking about student learning. We designed a set of tasks to assess how students use crosscutting concepts to express their understandings as they constructed explanations for various natural phenomena. These tasks were based on previous work done by our research group in which we developed a set of conceptual metaphors to describe the ways students use CCCs. After using a holistic rubric to identify high quality responses, we returned to the framework set by these conceptual metaphors for further analysis in order to describe the concept of role selection. We found that students reasoned differently with CCCs in different contexts through their selection of the role their CCC understanding should take and that we, as assessors, inadvertently dictated those explanatory contexts through the phenomena we asked students to explain and through the wording of the task.