Pre-Conference Workshop—Equity and Ethics Committee Sponsored (Free – 60 participants max)
Becoming Next Generation Science Educators in an Era of Global Science Education: An Equity Perspective
8:00am – 12:00pm, Grand B
Organizers:
Jerome Shaw, University of California, Santa Cruz
Philip Boda, Columbia University
Cassie Quigley, Clemson University
Francesca White, Indiana University
ABSTRACT:
The Equity and Ethics Committee sponsors this annual pre-conference workshop for scholars of color and individuals interested in scholarship involving equity and social justice, centered on this year's theme addressing globalization. This year participants will engage in critical dialogue about the Next Generation Science Standards (NGSS), both its benefits and limitations. Discussions will be centered on their impact on research, practice, and policies, especially with regard to equity and social justice as it applies to a worldview mindset of science education. Workshop participants will engage in roundtable and panel discussions facilitated by dialogue with eminent scholars from varied research strands in science education. Participants will gain deeper and more nuanced notions of promoting equitable policy and practices related to the NGSS, and their implications for diverse learners throughout the world.

Pre-Conference Workshop—Research Committee (Free – 50 participants max)
Designing Adequately Powered Effectiveness Trials for Science Intervention Studies
8:00am – 12:00pm, Columbus EF
Presenters:
Jessica Spybrook, Western Michigan University
Joe Taylor, Abt Associates Inc.
Susan Kowalski, BSCS
ABSTRACT:
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—Research Committee (Free – 40 participants max)
Videocase-Based, Analysis-of-Practice for Teacher and Student Learning: How To's from a 10-year Line of Research
8:00am – 12:00pm, Wrigley

Presenters:
Jody Bintz, BSCS
Connie Hvidsten, BSCS
Kathleen Roth, Center for Excellence in Mathematics and Science Teaching (CEMaST), California State Polytechnic University (CPP)
Betty Stennett, BSCS
Christopher D. Wilson, BSCS

ABSTRACT:
This interactive workshop will develop participants' expertise in designing, implementing, and studying videocase-based, analysis-of-practice experiences to support the kinds of teacher learning needed to reach the vision of the Next Generation Science Standards. This "how to" session will draw from an extensive BSCS line of research and development that examines impact of videocase-based, analysis-of-practice PD on student learning in various contexts: elementary and high school settings; face-to-face, online, and blended settings; district-focused implementation vs. cross-district, etc. Participants will engage in two key components of the videocase-based, analysis-of-practice PD approach: (1) video analysis of classroom science teaching and learning through the lens of a research-based conceptual framework that focuses on a small set of carefully selected teaching strategies, and (2) video analysis of a teacher study group that is engaged in analysis-of-practice under the guidance of a PD Leader. Before and after engaging in these activities, participants will examine research findings and tools from a 10-year line of research that shows significant impact on student learning, teacher content learning, teacher PCK, and teacher practice. The workshop will close with a discussion about building a productive line of research led by researchers who developed and carried out the BSCS line of research. Participants will leave with access to a website that provides them a suite of tools and resources for both implementing videocase-based, analysis-of-practice PD and for studying and analyzing teacher and student outcomes.

Pre-Conference Workshop—Research Committee (Free – 50 participants max)
Developing International Cross-Cultural Research Projects on Science Education
8:00am – 12:00pm, Columbus KL

Presenters:
Hsiao-Lin Tuan, National Changhua University
Ling Liang, LaSalle University
Sarah Barrett, York University, Canada
Julia V. Clark, NSFNSF
Saouma BouJaoude, American University of Beirut
Hsiao-Lan Sharon Chen, National Taiwan Normal University
Mauricio Pietrocola, University of San Paulo
Peter A. Okebukola, Lagos State University, NigeriaNigeria

ABSTRACT:
This workshop is designed for those who are interested in developing international cross-cultural research projects on science education. At the workshop, five projects will be presented by leading science education researchers in the international community. These projects will be used as a basis for small group discussion of the challenges associated with international, cross-cultural research. Participants will be engaged in discussions on the identification of future cross- cultural research topics, methodology, and challenges in conducting cross-cultural research.

Pre-Conference Workshop—Research Committee (Free – 30 participants max)
Key Challenges and Future Directions for Research on Scientific Argumentation

8:00am – 12:00pm, King's Columbus IJ

Presenters:

Bryan Henderson, Arizona State UniversityUniversity
Katherine McNeill, Boston CollegeCollege
Amanda Knight, Boston CollegeCollege
Maria Pilar Jiménez-Aleixandre, University of Santiago de Compostela, Spain
Victor Sampson, University of Texas at Austin
Jonathan Osborne, Stanford University
Amelia Wenk Gotwals, Michigan State University
Leema Berland, University of Wisconsin-Madison
Carla Zembal-Saul, Pennsylvania State University

ABSTRACT:

Argumentation is one of the most rapidly growing strands of science education research. Amidst this rapid growth is a dynamic array of research programs with varying methodologies, units of analysis, analytic frameworks, and operational definitions that can be used to support and study argumentation inside classrooms or technology-enhanced learning environments. From this research has emerged multiple curricular, pedagogical, professional development, and assessment challenges. The objective of this workshop is to bring together leading researchers in the argumentation strand for a focused and critical discussion about possible future directions the field should pursue in light of these challenges. Moreover, this workshop aims to encourage greater collaboration across research groups, particularly given a conference theme that emphasizes global science education. A critical discussion some of the most pressing challenges currently faced by the argumentation strand presents an opportunity to bring diverse perspectives together to tackle these specific challenges and hence move the field forward. The workshop will be divided into three main focus areas: (1) Supporting Student Argumentation; (2) Assessing Student Argumentation; (3) Supporting Teachers in Fostering Argumentation. Facilitated by experts in each of these areas, the goal will be to generate a formal list of key challenges and recommendations for future research directions. Participants will then have the option of sharing this list with additional colleagues through invitation to an online survey that solicits feedback on the recommendations advanced by the workshop proceedings. Together, the results of the workshop proceedings and the subsequent online survey will be documented for all in both a white paper and through submission to a peer-reviewed journal.

Pre-Conference Workshop—Publications Advisory Committee (Free – 60 participants max)

Submitting and Reviewing Proposals to NARST Strands

10:00am – 12:00am, Grand A

Part A (10:00am – 11:00am): Submitting Proposals to NARST Strands

Presenters:

Huann-shyang Lin, National Sun Yat-sen University
Huihui Kanahele-Mossman, Ka Umeke Ka'eo
Alberto Rodriguez, Purdue University

ABSTRACT:

The purpose of this part of the workshop is to aid NARST members, especially those whose native language is not English, in preparing proposals able to be reviewed and accepted through the peerreview process, thereby enabling their papers to be presented in the desired format at the NARST Annual International Conference. The presenters will be native speakers of languages other than English.

Part B (11:00am – 12:00pm): Reviewing Proposals for NARST Strands

Presenters:

Huann-shyang Lin, National Sun Yat-sen University
Huihui Kanahele-Mossman, Ka Umeke Ka'eo
Alejandro J. Gallard M., Georgia Southern University

ABSTRACT:
The purpose of this part of the workshop is to aid NARST reviewers, especially those who review proposals of NARST members whose native language is not English, to be able to evaluate the quality of the proposals. The presenters of this session will aid reviewers to understand the process of how to approach some of the language issues to determine the potential contributions of the proposed research and/or theoretical position to science education.

Concurrent Session #1
1:00pm – 2:30pm

Presidential Sponsored Session
Exploring Methodological Directions to Support a NGSS-Driven Research and Development Agenda
1:00pm - 2:30pm, Comiskey

Discussants:
Valarie Akerson, Indiana University
Joseph Taylor, Abt Associates Inc.
Presenters:
Jonathan Osborne, Stanford
Sharon Lynch, George Washington University
Eileen Carlton Parsons, University of North Carolina, Chapel Hill
Dale Baker, Arizona StateState University
Jim Pellegrino, University of Illinois, Chicago

ABSTRACT:
This interactive panel session will provide opportunities for participants to discuss the contributions of contemporary research methods to a Research and Development Agenda for the NGSS. Panelists will focus on the core research questions from A Framework for K12 Science Education (NRC, 2012) and the implications of these questions for research methods. In particular, panelists will address the following questions: 1. What are the typical preconceptions that students hold about the practices, crosscutting concepts, and core ideas at the outset? 2. What is the expected progression of understanding, and what are the predictable points of difficulty that must be overcome? 3. What instructional interventions can move students along a path from their initial understanding to the desired outcome? 4. What general and discipline-specific norms and instructional practices best engage and support student learning? 5. How can students of both genders and of all cultural backgrounds, languages, and abilities become engaged in the instructional activities needed to move toward more sophisticated understanding? 6. How can the individual student's understanding and progress be monitored?

Strand 1: Science Learning, Understanding and Conceptual Change
Using Data and Evidence in Scientific Practices
1:00pm - 2:30pm, Wrigley
Presider: Katherine Culp, Education Development Center, Inc.

How Learning During Scientific Observation can Influence Students' Reasoning with Evidence

Thanh K. Le, University of Maine
Emily J. Silver, University of Maine

Jonathan T. Shemwell, University of Maine
Daniel K. Capps, University of Maine
Christine E. Voyer, Gulf of Maine Research Institute
Marie Daigle Thompson, University of Maine

ABSTRACT:
Learning that occurs within student observations that comprise “collecting evidence” needs to be better understood in science education. Perceptual learning theory suggests that there may be an association between how students observe phenomena and how well they reason about their observations to rule out plausible alternative claims. Using this theory, we formed the hypothesis that distinguishing features of a phenomenon from a set of contrasting alternatives would help learners encode the importance of observed features for ruling out these alternatives. We tested this hypothesis in a study of middle school students use of evidence for field identification. We showed that observers using contrasts ruled out alternative claims at a higher rate than those to whom plausible alternatives were otherwise made highly salient. We also showed that the process of perceiving features from among contrasting alternatives was tightly related to ruling out alternative claims. These findings argue for the deliberate use of contrasts to support observation leading to evidence. They also suggest the general importance of paying attention to students’ processes of observation within the practice of science.

Investigating Student Interpretation of Authentic Biological Data through Argumentation and Use of Models

Patricia Zagallo, University of Arizona
Raj Shah, University of Arizona
Shanice Meddleton, University of Arizona
Molly Bolger, University of Arizona

ABSTRACT:
There is a call to reform science education to better engage students in scientific thinking and scientific practices. This paper focuses on how students interpret authentic biological data using biological models. Audio recordings were collected from groups of undergraduate students participating in data interpretation as part of their in-class work within a large, upper-division cell and developmental biology course. Analysis of transcripts revealed spontaneous argumentation, primarily used by students as a sensemaking tool to build interpretations of data. Rather than persuasive argumentation, dialog included frequent co-construction of claims backed by evidence from data. Analysis of written artifacts demonstrated that working together students most often formed interpretations that include inferences about data, beyond literal descriptions. Findings suggest that students used argumentation in combination with biological models to broaden the scope of interpretations beyond the data figure to include biological context or significance. This study has implications for understanding coordinate use of multiple scientific practices in classrooms and for design of instruction that supports interpretation of data in undergraduate courses.

Sampling in the Wild: How Attention to Variation Supports Middle School Students' Sampling Practice

Michelle Cotterman, Vanderbilt University
Richard Lehrer, Vanderbilt University
Leona Schauble, Vanderbilt University/Peabody College

ABSTRACT:
In professional practice, scientific claims are made in light of how data are constructed. Yet students are rarely invited to grapple with the complexities of such practice. This paper describes a design study in which six classes of sixth-grade students spent approximately three weeks investigating a local creek. The goal of this design study was to better understand how students’ scientific and statistical practices, such as sampling, develop within the context of ecological fieldwork. We drew on focus student interviews and records of practice including student artifacts and video recordings of student activity to identify and trace shifts in students’ sampling practice across their investigation of the creek. Our findings suggest three ways in which students’

attention to variation within the context of their ecological investigations supported the development of a more sophisticated practice of sampling.

Functional Roles of Inscriptional Evidence in Children's Written Arguments about Socioscientific Issues

Sihan Xiao, University of California, Los Angeles
William A. Sandoval, University of California, Los Angeles

ABSTRACT:
Engaging science in everyday situations often means not advancing knowledge but evaluating available evidence for given claims. In everyday situations, evidence is usually presented in some type of inscription (e.g. tables, diagrams, photos). We present a study that ask what children think counts as evidence, and how they use forms of inscriptions to argue about socioscientific issues. Through a theoretical lens that sees argumentation as not only a cognitive process but also a social endeavor of persuasion, we conducted content analyses on 104 elementary students' written arguments. Results show that depending upon the particular issue to be argued about, students might include and defend counterarguments to rhetorically strengthen their own position. Students also use a set of rhetorical strategies to functionally deploy inscriptions in their arguments to make particular claims persuasive. Further, students were able to coordinate different types of inscriptions and claims. Understanding how students perceive, interpret, and deploy different kinds of evidence in socioscientific issues provides educators with a valuable resource for identifying and building upon productive strategies through science teaching in order to answer the call in the Next Generation Science Standards for critical consumers of scientific information related to students' everyday life.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Epistemology and Science Learning
1:00pm - 2:30pm, Water Tower
Presider: Joao Fernandes, New University of Lisbon

Teaching "How-to" and "Why" – Does supporting Procedural Knowledge and Procedural Understanding Improve Inquiry Learning?

Julia C. Arnold, RWTH Aachen University, Germany
Kerstin Kremer, RWTH Aachen University
Jürgen Mayer, Kassel University, Germany

ABSTRACT:
Inquiry competence is described as the successful usage of problem solving procedures on scientific problems in the natural world and it requires procedural knowledge, content knowledge and procedural understanding. In order to enhance inquiry competence, inquiry learning is widely recommended as teaching method. However, there is much discussion about the degree of openness in inquiry learning, which is the relative instructional support or guidance. It is a challenge to teachers to decide about when to give support and when to hold back information in order to maintain authentic inquiry settings. The effect of two support methods (help cards and concept cartoons) was investigated within a 2x2 factorial quasi-experimental intervention study with pre- and posttest. T-tests (paired comparisons) showed most significant learning progress with large effect sizes for all groups concerning the tested inquiry competence, content knowledge and procedural understanding. Concerning inquiry competence, nested ANOVA with planned contrasts further revealed, that having either help cards or concept cartoons significantly increased competence-development to having no treatment, while the combination of both supports did not differ significantly from control group. The paper discusses these findings and gives implications for science classrooms.

Prompting Adolescents' Epistemic Beliefs in a Field-based Science Program: An Exploratory, Mixed Methods Study

Jiangyue Gu, Utah State University
Brian R. Belland, Utah State University

ABSTRACT:
This study employed a mixed-methods approach to examine 1) middle and high school students' expressed epistemic beliefs (quantitative) and epistemic beliefs revealed from practice (qualitative) during a problem-based, scientific inquiry unit, and 2) explored how and why students' epistemic beliefs change by engaging in PBL. Preliminary findings indicated that middle and high school students' epistemic beliefs became significantly more sophisticated by engaging in PBL. Initial results of this study showed that students who hold sophisticated self-reported epistemic beliefs may also apply such sophisticated beliefs to their scientific inquiry practice. Such findings can potentially help researchers to better understand the relation between students' epistemic beliefs and their inquiry practice.

Investigating the Level of Relationship between Turkish Elementary Students' Personal Epistemologies and Self-regulated Learning

Muhammet Mustafa Alpaslan, Mugla Sitki Kocman University
Fatma Alpaslan

ABSTRACT:
The purpose of this study was to determine the level of the relationship between the Turkish elementary school students' personal epistemologies, achievement goals, learning strategies, and achievement. Three-hundred-twenty-two elementary school students (4th Grade through 8th Grade) in Turkey participated in the study. Results from the structural equation modeling showed that students' personal epistemologies influence both their motivation and meta-cognitive strategies to learn science. Viewing science as an accumulation of facts lead the students to have low motivation in learning science, not to engage meta-cognitively into learning task, and to have low achievement in science. Implications and future direction are discussed.

Contextual Effects on Student Reasoning: Physical Anthropology as an Alternative Discipline for Learning Biological Evolution

Elizabeth P. Beggrow, The Ohio State University

ABSTRACT:
Prior research across science domains has shown that context makes a difference. Within evolution education research, students' evolutionary knowledge and naïve ideas may vary depending on the specific contextual features of assessment items. These studies illuminate issues of contextuality in evolution education, but have focused on biology populations to the neglect of alternative disciplines that use evolutionary theory as their framework, such as physical anthropology. In anthropology, evolution is situated within the context of humans, which could provide various cognitive advantages for reasoning about evolution. This study investigates differences in reasoning patterns between university biology and anthropology students' explanations of human and nonhuman evolutionary change. Although the biology students had greater knowledge of and experience with biological concepts in general, directly following evolution instruction, biology students demonstrated a decreased ability to reason about human evolutionary change, while anthropology students showed no differences in their reasoning between contexts. Furthermore, when experience and knowledge were held constant, anthropology students were more likely to use key concepts of evolution in their explanations when asked about trait loss, compared to the biology students. These findings provide evidence for cognitive advantages in learning evolutionary concepts within the context of human evolution.

A Classroom Community of Practice and an Epistemic Frame within an Instantiation of Modeling-based Instruction

Todd Campbell, University of Connecticut

ABSTRACT:

This research investigated the epistemic frame of an instantiation of modeling-based instruction (MBI). A high school physics classroom was recorded and analyzed. Qualitative methods were employed to characterize the epistemic frame in terms of the science practices used, teacher and student roles, and the patterns in classroom episodes found in the context of MBI. Results indicated that a significant amount of valued science practices were identified within the MBI epistemic frame. The teacher's role within the MBI frame was described as, among other things, engaging individuals and community, facilitating discussion, listening, and helping students reflect. Examples of students' roles identified were performing experiments, collecting data, interpreting findings, and explaining phenomena. When considering patterns in classroom episodes, shifts in student responses to questions from definitive answers lacking justification to reflective claims made, based on evidences and science principles, were found as students began to engage in the science practices of modeling and investigation. Additionally, a pattern was found whereby students generally reasoned with empirical assessment, or correspondence, to physical reality before consideration was given to rational assessment, or alignment, with accepted scientific knowledge. Implications for MBI and further considerations related to epistemic frames are discussed.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Self-efficacy and Student Interests
1:00pm - 2:30pm, Grand Suite 5
Presider: Alandeom W. Oliveira, University at Albany, SUNY

Spark to Flame: Factors Influencing Students' Interest in Science
Christina S. Melki, Indiana University
Russell N. Balliet, Indiana University
Adam V. Maltese, Indiana University
Robert H. Tai, University of Virginia
John T. Almarode, James Madison University
ABSTRACT:
To ensure a large number of people in science, technology, engineering, and mathematics fields, the evolution of interest in those fields and the factors related to an individual's pursuit of a career in them must first be identified. This pseudo-longitudinal study examines these through surveys given to 25 schools (elementary, middle, and high school) during each semester over two years. The surveys were designed to identify 3rd-12th grade students' career expectations and their possible correlations with knowing an individual in a science-related field, among other things. The data presented here are from the preliminary analysis, in which statistical analyses suggest many students' career interests lie in science-related fields and, though they evolve over time, they generally align with traditional gender roles. In addition, students' association with an individual who holds a science career frequently correlates with the student expecting a career in the same field. These findings reveal students' scientific interests at various ages, which science teachers can use as contexts for science lessons, yielding heightened interest for the age group, and researchers can use as a context for future work examining the elements of students' persistence in the science field throughout time.

Investigating the Relation of Self-Efficacy to Achievement and Engagement in Science by Considering Big-Fish-Little-Pond Effect
Yasemin Tas, Ataturk University
Sundus Yerdelen, Kafkas University
Nurcan Kahraman, Çanakkale Onsekiz Mart Üniversitesi
ABSTRACT:
The purpose of this study is to examine how students' gender, socioeconomic status, science achievement, and engagement dimensions (motivational and behavioral engagement) predict students' self-efficacy in science by

considering Big-Fish-Little-Pond Effect (BFLPE). In order to test the research questions, TIMSS 2011 dataset that was obtained from Turkey was used. Sample includes 6928 eight grade students. Results of HLM analyses showed that 10% of the variance in students' self-efficacy in science learning can be explained by class level variables. While at the student level, science achievement, socioeconomic status, liking science, value science, and behavioral engagement was found to be positive significant predictors of Self-efficacy in science; at the class level, aggregated classroom science achievement was found to be negative significant predictor of self-efficacy. All level-1 predictors accounted for approximately 57% of the student level variance in students' self-efficacy in science. Additionally, 7% of the between class variance in self-efficacy was explained by aggregated classroom science achievement.

The Relations between Teachers and Parents' Messages and Adolescents' Self-Efficacy for Science Learning
Bat-Shahar Dorfman, Weizmann Institute of Science
David L. Fortus, Weizmann Institute Of Science
ABSTRACT:
Self-efficacy, a key element of social cognitive theory, is associated with motivation, effort, persistence, engagement in activities, and academic achievements – both generally and for STEM disciplines. This study examined the relations between social persuasion and students' self-efficacy for science learning by focusing on students' perceptions of the explicit and implicit messages their science teachers and their parents related to their ability in science. Data was collected from 1800 5th to 9th grade students from 15 schools. Results of multivariate regression analysis show that across both genders, different school types and grades, the strongest predictor of students' science self-efficacy was students' perceptions of what their parents think about their ability to succeed in science learning. Girls' self efficacy was also predicted by the verbal messages they get from their science teacher. Results also show that as students mature and in certain educational environments (e.g., Waldorf schools) what the science teacher is perceived to be thinking about students' ability to succeed in science learning was also a strong predictor of students' science self-efficacy. The results of this study offer insights into the issue of adolescents' decline in science self-efficacy, which is a possible cause of distancing from science learning.

The Study Habits of Engineering Undergraduate students in India and USA: A Comparative Qualitative Analysis
Devasmita Chakraverty, University of Virginia
Kathan Shukla, University of Virginia
ABSTRACT:
We conducted an exploratory qualitative study comparing the study habits of eight undergraduate engineering students in India and the US. Using grounded theory, we found that study habits tended to be affected by: educational assessment; personal commitment & goals; social influence; and self-correction of study habits based on personal experiences. We also examine how these factors produce similarities and differences in study habits among both groups of engineering students.

Assessing the Biology Learning Environment at a HBCU - Year 1 of a 5-Year Study
Catherine S. Martin-Dunlop, Morgan State University
ABSTRACT:
This mixed-methods study assessed students' perceptions (N=182) of their undergraduate biology learning environment at a Historically Black College and University (HBCU) in the mid-Atlantic region of the United States. Students' actual perceptions were compared with what they would prefer in an ideal environment. Seven variables describing the learning environment were measured, namely, Open-Endedness, Formative Assessment, Involvement, Investigation, Task Orientation, Cooperation, and Clarity of Assessment Criteria. Also, two scales assessed students' attitudes and one scale assessed academic self-efficacy. All 10 scales came from highly valid and reliable instruments. Results revealed average item means for actual perceptions ranged

from 3.06 for Open-Endedness (sometimes occurs) to 4.18 for Task Orientation (often occurs). Means for what students would prefer ranged from 3.48 for Open-Endedness to 4.62 to Task Orientation. The narrowest gap (0.29) between actual-preferred scales was for Cooperation. The widest gap (1.26) was for Clarity of Assessment Criteria. Statistically significant differences ($p<0.05$) were found for four learning environment scales. Attitudes towards scientific inquiry, enjoyment of lessons, and academic self-efficacy reveal areas that need considerable improvement. Interviews with students complemented the quantitative data, and many suggestions for improving the learning environment to more actively engage students in the learning process were made

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Related Paper Set - Research on Engineering Education in the Elementary Grades
1:00pm - 2:30pm, Columbus GH
Presider: Gregory J. Kelly, Penn State University
ABSTRACT:
Engineering has entered into the reform movement in science education through the Next Generation Science Standards (NGSS Lead States, 2013). This marked change provides new opportunities to examine the educational affordances of the application of science concepts to solve real-world design challenges. This session examines a range of issues concerning engineering education in the elementary grades including the academic and social consequences of working toward the generation of multiple, plausible solutions that meet a set of design constraints. Each of the five studies is situated in classroom life and draws from extensive data sets of discourse practices. The topics studied include the framing of disciplinary knowledge and practices in engineering, the value of failure and persistence for problem solving, the language demands of collaborative engineering design, the ways that students position themselves and knowledge claims through notebooking, and cultural production of what and who counts as smart in engineering. Implications are drawn for curriculum design, scaffolding student designs, building affiliation to science and engineering, and teacher education.

Engineering Design as a Disciplinary Discourse: An Exploration of Language Demands and Resources among Urban Elementary Students
Kristen B. Wendell, University of Massachusetts Boston
Patricia Paugh, University of Massachusetts Boston
Christopher G. Wright, University of Tennessee, Knoxville

Engineering Practices through Notebooking
Jonathan D. Hertel, Museum of Science, Boston
Christine M. Cunningham, Museum of Science, Boston
Gregory J. Kelly, Penn State University

Shifting Cultural Meanings of "Smartness" through Engineering in High-needs Elementary Classrooms
Heidi B. Carlone, University of North Carolina at Greensboro
Tess Hegedus, University of North Carolina at Greensboro
Megan Martin, University of North Carolina at Greensboro
Aundrea Carter, University of North Carolina at Greensboro

Framing Engineering Practices in Elementary School Classrooms
Christine M. Cunningham, Museum of Science, Boston
Gregory J. Kelly, Penn State University

The Engineering Design Process as a Safe Place to Try Again: Perspectives on and Responses to Failure by Elementary Teachers and Students
Pamela S. Lottero-Perdue, Towson University

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Science Teachers' Learning and Retention
1:00pm - 2:30pm, Randolph
Presider: Erin M. Furtak, University of ColoradoColorado

Using Pedagogical Reasoning to Explicate Expert Practice that Aligns with National Teaching Standards
Stephen Keast, Monash University
Ian Mitchell, Monash University
Debra Panizzon, Monash University
Melissa Tham, Monash University
John Loughran, Monash University
ABSTRACT:
This paper reports a study investigating the pedagogical reasoning (PR) of expert science teachers in order to explicate how they develop and refine the skilled practice called for, but typically not elaborated in system-level teaching standards. In a precursor study, four interconnected foci emerged as a framework to elucidate the tacit pedagogical reasoning of a group of skilled teachers; big ideas, quality learning, student engagement and contextual constraints. This study explored whether these PR foci would map onto and help explicate and extend the practices of a new cohort of elementary and secondary teachers. Data was collected over a two day introductory session with participants, from their on-going practice as they digitally-recorded their lesson planning and review and in follow up interviews. The authors report that these teachers resonated with all four foci, though space limitations mean this paper reports on the many aspects of quality learning that the teachers promoted Analysis of recordings of PR showed that the teachers thinking bounced around between the foci in a non-linear and highly interactive way – labelled 'pinball reasoning.' This reflects the multi-faceted and interconnected nature of skilled teaching and has implications for how standards might be used and supported.

Preservice Experiences on Science Teacher Attrition
Jonah B. Firestone, Washington State University-Tricities
Sissy S. Wong, University of Houston
Eunjin Bang, Iowa State University
Julie A. Luft, University of Georgia
ABSTRACT:
Few empirical studies in education explore how preservice preparation programs relate to science teacher attrition. This is a critical area to study as well-designed teacher preparation programs may provide important experiences that reduce early career science teacher attrition. In order to study this notion, a mixed methods study was conducted that explored how different components of teacher preparation programs related to teacher attrition. Data from a five-year longitudinal study of beginning secondary science teachers in the United States (n =130) were used to conduct two-way contingency table analyses to examine statistical differences between those leaving teaching ("leavers") and those remaining in teaching ("stayers"). The results of this analysis indicated significant differences between the length of student teaching and the decision to leave or stay in teaching. In order to understand the decision process among teachers who left teaching, interviews were conducted with these teachers and they were analyzed inductively in order to understand their perspectives about leaving teaching. Categories from this analysis were compared with the quantitative results in order to understand a teacher's decision to leave teaching. Based on the results, we suggest that in the early years of

teaching, the quality of a preservice preparation program may impact the amount of time a teacher persists in the classroom.

Learning Progressions, Formative Assessment, and Professional Development: ResultsResults of a Longitudinal Study

Erin M. Furtak, University of Colorado
Katharina Kiemer, TUM School of Education
Vanessa de Leon, University of Colorado
Rebecca D. Swanson, University of Colorado, Boulder

ABSTRACT: The teaching practices of eliciting and responding to students' ideas in the course of instruction are often called formative assessment, and require teachers to have deep knowledge of student ideas within a domain, as well as to be able to flexibly respond to student thinking during instruction. These qualities of being able to efficiently and innovatively take up student ideas may be related to the development of adaptive expertise, or the optimal balance between efficiency and innovation in classroom practice. In this paper, we analyze data from a four-year longitudinal study in which we engaged nine high school biology teachers from three schools in on-site professional development centered on a learning progression for natural selection to support their ability to identify and interpret student thinking, as well as to design and enact formative assessment activities. Results indicate that the majority of teachers became more efficient at identifying and interpreting student ideas, and many - but not all - became more innovative in terms of their design or enactment of the assessment activities. We correlate these changes in practice are correlated with changes in student learning, and frame our results in terms of studies of teacher adaptive expertise.

Making a New High School Chemistry Teacher's Struggles with Classroom Assessment Visible

Kemal Izci, Necmettin Erbakan University
Marcelle Siegel, University of Missouri-Coluimbia

ABSTRACT:
Assessing student learning to adapt instruction is an important skill all teachers need to develop. However, it is not an easy task for teachers even more difficult for novice teachers. Limited studies have been conducted on novice chemistry teachers' understanding and practices of assessment. The current study aims to explore a novice chemistry teacher's understanding and practices of assessment to help educators and researchers for supporting prospective and novice teachers. This study used a single case study design to explore the novice teacher's assessment literacy. The results suggest that, in theory, the teacher's understanding of assessment aligned with current view of assessment as she mostly valued formative function of assessment to support conceptual learning, motivation, and metacognition. However, in practice, the teacher did not select and use appropriate assessment tasks to accomplish her aims, such as supporting conceptual learning. There are some factors-lack of materials, time/workload, content knowledge, teaching experience, and colleague support-identified based on reflective interviews as reasons for the discrepancy between her understanding and practices of assessment. We suggest that prospective and novice teachers need to observe and experience successful assessment practices in order to learn how to transfer their understanding of assessment into classroom practices.

Practices for Whole Assessment Processes of Science Teachers: Exploring Collaboration in Communities of Practice

Heejung Min, Chongryang Middle School
Seoung-Hey Paik, Korea National University of Education

ABSTRACT:
The purpose of this study was to explore the assessment practices of science teachers with their colleagues, using constructed-response questions. The research questions addressed how teachers assessed student work with colleagues through a series of step-by-step processes, and what factors affected teacher behavior and

decisions in the school context. Four science teachers in one middle school participated in this study. The teachers who taught the same grade, worked together as a small community-of-practice. Each teacher revealed more than 10 lessons, and all the processes related to assessment of three exams, which included discussion in the community-of-practice. Each was also interviewed more than three times. The findings showed the teachers were struggling, along with their colleagues, to provide a reasonable judgment about student achievement throughout the whole assessment process. They cooperated or conflicted with each other according to the cases. The teachers considered many factors that came from PCK, belief, and assessment context, to review with colleagues, and arrived at a conclusion. Their practice within the community had two opposite effects. They were able to provide more valid and fair rubrics to all students. However, their unique PCK and belief were sacrificed. Further research topics and implications were discussed.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Related Paper Set - Designing Next Generation Post-Secondary Science Learning, Teaching, and Communication Experiences and Environments
1:00pm - 2:30pm, Columbus IJ
Presider: Sania Z. Zaidi, University of Michigan
Discussant: Philip Bell, University of Washington
ABSTRACT:
This collection of papers reports on research taking place in post-secondary science education contexts, and examines what implications the Framework for K-12 Science Education and the Next Generation Science Standards have for college science education at the undergraduate and graduate levels. We showcase four design projects that we argue are NGSS-framed examples of post-secondary science learning and teaching. With our design work, we seek to address questions such as: (a) How can we design classroom experiences that provide rich learning opportunities for undergraduate students in the sciences?, (b) How can we design experiences that help apprentice graduate students in the sciences into teaching practices that will promote deeper learning?, (c) How can we design learning experiences that help graduate students in the sciences and engineering better communicate their research to lay-audiences, and (d) What models exist for both vetting design work, and related research, as well as providing professional development for science education designers at the post-secondary level? With this collection of papers, we wish to dialogue with other NARST members who are working to bring visions of the Framework and the NGSS to post-secondary science education through the design of Next Generation curricula, teaching experiences, and professional development initiatives.

Using Student Generated Explanations of Physical Chemistry Concepts, as well as a Peer-Review Process, to Explore Student Conceptual Understanding
Heidi Phillips, University of Michigan

A Designed Professional Development Program to Encourage Graduate Student Instructors to Use Active Learning in Chemistry Discussion Sections
Rachel A. Barnard, University of Michigan

RELATE: Improving Lay-Audience Science Communication among STEM Graduate Students Using a Practice-Based Model
Katherine E. Prater, University of Michigan
Elyse L. Aurbach, University of Michigan

Employing a Studio Model for Designers of Science Learning and Teaching Artifacts and Environments: Tinkering, Critique, and Dialogue
Leah A. Bricker, University of Michigan

Strand 6: Science Learning in Informal Contexts
Related Paper Set - Climate beyond the Curriculum: Learning about Climate Change in Informal Contexts
1:00pm - 2:30pm, Roosevelt
Presider: Noah Weeth Feinstein, University of Wisconsin-Madison
ABSTRACT:
This related paper set examines thinking and learning about climate change across informal contexts. Climate change is the focus of myriad learning interactions, both in designed settings and in the daily lives of private citizens who are engaged in activism, contemplating behavior change, or simply trying to make sense of science in the news. Climate science is complex, dynamic, and contested, so these everyday learning interactions provide unusually rich opportunities to study the challenges of public engagement with science, more generally. Informal learning environments are crucial to the study and practice of climate change education. Recent, highly charged political debates over the Next Generation Science Standards remind us that there are still formidable obstacles to teaching and learning about climate change in schools. As a result, informal learning environments are often the only educational contexts where climate change can be explored in great detail. In keeping with the breadth and richness of the field, the papers in this set cut across the research-practice continuum and span a broad range of informal contexts, including mass media, community discussion, video games, citizen science, and museum-community collaborations.

Climate Change in the Community: Reflections from a Sustainability Semester
Hannah K. Miller, Michigan State University
Elizabeth X. De Los Santos, Michigan State University
Charles W. Anderson, Michigan State University

Participatory Development and Evaluation of the WeatherBlur Citizen Science Project
Ruth Kermish-Allen, Island Institute
Karen Peterman, Karen Peterman Consulting
Christine Bevc, University of North Carolina

Toward Outsider Competence: Informed Assessments of Climate Science in Popular Media
Shusaku Horibe, University Of Wisconsin- Madison
Noah Weeth Feinstein, University of Wisconsin-Madison

A View from Practice: Exploring Adaptation in the Climate of Uncertainty Initiative
Patrick Hamilton, Science Museum of Minnesota

Coming to Grips (or Not): Using a Climate Change Simulation Game to Develop Systemic Understanding
David I. Waddington, Concordia University

Strand 6: Science Learning in Informal Contexts
Strand Sponsored Session - Translating Theory into Practice in Informal Settings
1:00pm - 2:30pm, Grand D North
Presider: Gary Holliday, University of Akron

Developing K-12 Inquiry Practices
Tom J. McConnell, Ball State University
J. M. Shireen Desouza, Ball State University
Tolly Foster, Indianapolis Zoo
Michele Schilten, Indianapolis Zoo
ABSTRACT:
Teaching inquiry science is an important goal of the Next Generation Science Standards (NRC, 2013). While content knowledge is still important, "practices of science" bring the processes to forefront. Teachers need opportunities to develop authentic and engaging inquiry lessons that feature the practices. The [name of teacher academy deleted for review] fosters interaction with researchers who use the practices to facilitate teachers' implementation of the practices. The Center is a new exhibit at a Midwestern that serves as both an exhibit and a research facility. Researchers study learning and cognition in the primates using touch screen computers, and keepers use practices like questioning, observation, data collection, analysis, and proposing solutions to care for the animals. Teachers in the PD learn about orangutans, their environment, threats to their survival in the wild, and the cognition research. Discussions focus on the practices and their application to standards. Teachers develop inquiry lesson plans to use in the following school year, and engage in ongoing reflection and revision. The project examines the design of the PD program, its impact on teacher practices, and student learning outcomes. The presentation will share program design and data collected in the pilot program.

A Study of Theory to Practice in an Informal Science Learning Environment
Stephanie Bohr, John G. Shedd Aquarium
Susan Magdziarz, John G. Shedd Aquarium
Manda Smith, John G. Shedd Aquarium
ABSTRACT:
That a learning theory can and should be applied to program planning and evaluation is not a new concept for the field of education. However, for informal learning sites, program realities often do not allow for best practices. This study explores the extent to which a pre-identified theory, in this case Connected Learning, can be incorporated into practice in a teen learning space at a large urban aquarium. Preliminary findings indicate that even when a theory is intentionally selected and incorporated into a plan prior to program design and implementation, it is not necessarily utilized in day-to-day program planning and operations. Findings also demonstrate that a theoretical frame can ground evaluation and understanding of learning and influence future iterations of the program, which can potentially lead to better alignment of theory and practice. Better understanding of the realistic interplay between theory and practice may help other informal science educators and researchers plan and evaluate for theory, in addition to traditional outputs and outcomes. The findings also demonstrate that Connected Learning theory may be of use as a theoretical frame for other informal teen spaces with similar goals and interests.

Building a Collaborative Learning Research Agenda for UK Natural History Museums
Emma Pegram, Natural History Museum, London
ABSTRACT: Not found in abstract submission system.

Strand 7: Pre-service Science Teacher Education
Teachers' Understandings of Science and Use of Student Representations
1:00pm - 2:30pm, Columbus KL
Presider: Jason Katzmann, University of Wyoming

Prospective Science Teachers' Understanding of Science and Engineering Practices
Stacey L. Carpenter, University of California - Santa Barbara

Ashley Iveland, University of California - Santa Barbara
Sungmin Moon, University of California - Santa Barbara
Sarah Hough, University of California - Santa Barbara
Julie A. Bianchini, University of California, Santa Barbara

ABSTRACT:
We investigated prospective physical science teachers' understanding of the eight science and engineering practices described in the Next Generation Science Standards (NGSS Lead States, 2013). Twelve undergraduates participated in a scholarship program created to address the recruitment of chemistry, physics, engineering, and computer science majors into high-need secondary schools. In this program, prospective teachers from these majors had the opportunity to "intern" in innovative secondary physical science and engineering classrooms. We asked: 1) What opportunities did interns have to observe secondary science students engaging in the eight science and engineering practices? 2) What did interns understand about these practices and how to implement them in classrooms? We qualitatively analyzed individual intern interviews, teacher focus-group interviews, and video records of class sessions. The opportunities interns had to observe classroom implementation of the practices varied by context, with project- and reform-based learning environments having more opportunities than a traditional classroom environment. Interns' understanding of the practices varied by practice: Interns exhibited more understanding of some practices over others.

Pre-service Teachers and Science: The Effect of Peer Instruction

Sally Blake, Flagler College
Barbara Blonder, Flagler College
Jeremy Krause, Flagler College
Candice Burkett, University of Illinois Chicago

ABSTRACT:
This study investigates the use of peer instruction through a social-constructivist view as an approach to teaching pre-service teachers. The sample was two sets of students, one group enrolled in a life science content course and one group enrolled in a science methods course. Instruction in the content course was a small group project that included an online simulation. There was no faculty instruction on selected science topics to the methods students. The students in the content course instructed the pre-service teachers on the topic of evolution and adaptation and then both groups worked together to plan and implement a lesson to AVID students from a local middle school. The college students were pre- and post-tested Participants scored significantly higher on the post-test ($M=13.90$, $SD = 4.00$) than on the pre-test ($M=10.86$, $SD=2.80$), $t(28) = 3.50$, $p< .01$. The findings of this study support the work of Eric Mazur (2014) concerning the use of peer instruction as an approach to science teaching.

Exploring Science Education Faculty Attitudes Toward Standardized Testing

Tyler L. St.Clair, Oregon State University
Jennifer Maeng, University of Virginia
Randy L. Bell, Oregon State University
Lindsay B. Wheeler, University of Virginia

ABSTRACT:
This investigation explored science education faculty members' perceptions about standardized testing before and after a professional development. All 16 participants taught preservice teachers at their respective institutions (9 from education departments, 7 from STEM departments). Prior to the PD, each participant described an issue encountered related to standardized testing and proposed a solution in writing. During the PD, participants engaged in small-group discussions about their narratives and collaborated to better understand issues surrounding standardized testing and to explore possible solutions. Data consisted of narrative texts, follow-up phone interviews, field notes, and artifacts from PD observations. Analytic induction was used to find emergent patterns in the data. Participants reported that test questions cover too much material and are limited

in scope to basic science facts and concepts. Participants also noted that standardized testing has harmful effects on ELL, low SES, and minority students. Proposed solutions included equipping preservice teachers with classroom assessment strategies aligned with best practices and recommendations for changes to standardized test formats. Following the PD, participants' proposed solutions changed to include greater agency in effecting change in policy at the state and nation levels.

An Action Research Study of Pre-Service Science Teachers' Use of Student Generated Representations

Jale Ercan, Gazi University
Mehmet F. Tasar, Gazi University

ABSTRACT:
The aim of this study was identifying pre-service science teachers' changes in views about using student generated representations in their science teaching practices after implementation of an action research. The participants of this study were 4 (3 female, 1 male) senior pre-service science teachers enrolled in science education program of a public university in the capital city of Turkey. The five-step process in the pedagogical action research design was taken as framework for this study. Two interviews implemented before and after action research were used as data sources. After the study, it is observed that pre-service science teachers gave more importance to student generated representations and had more positive views related to using them in science instruction. They mentioned that these kinds of representations improve students' active participation, interest and learning. Moreover, they claimed that preparing a lesson plan based on student generated representations and presenting it in a real classroom environment supported their professional development.

Strand 8: In-service Science Teacher Education
Teachers' PCK and Content Knowledge Development
1:00pm - 2:30pm, Columbus EF
Presider: Sherry A. Southerland, Florida State University

Teachers' Retention of Discipline-Specific Scientific Content Knowledge throughout a 3-Year Professional Development Program

Renee M. Clary, Mississippi State University
Anastasia Elder, Mississippi State University
James Dunne, Mississippi State University
Svein Saebo, Mississippi State University
Debbie Beard, Mississippi State University
Charles Wax, Mississippi State University
Josh Winter, Mississippi State University
Deborah Tucker, Independent Science Education Consultant

ABSTRACT:
The Hybrid Learning (HaLs) program provided middle school (US grades 6-8) teachers ($N = 81$) with intensive professional development (PD) in chemistry, geosciences, and physics. Because some teachers were retained and rotated into different disciplines, HaLs investigated retention of content 1-2 years beyond instruction. All teacher participants exhibited significant gains ($p < 0.001$) in chemistry, geosciences, or physics between incoming knowledge and the 10-day summer academy's conclusion. Chemistry and geosciences content were retained until the end of the PD year, but physics participants reported a significant loss ($p < 0.001$), although gains from incoming knowledge were significant. When retention was measured beyond the instructional year, only geosciences content was retained. Chemistry and physics teachers exhibited no significant differences between incoming knowledge, and content 1-2 years post instruction. We hypothesize that regression in chemistry and physics may result from persistent misconceptions. Geosciences gains may also reflect continued media exposure, better alignment to topics that participants taught, and/or better alignment of assessments with

the HaLs program. We propose that while discipline-specific PD resulted in significant learning gains, more research is needed into content retention after instruction, and mechanisms that would support and sustain teachers' content gains.

Developing Biology Teachers' Pedagogical Content Knowledge (PCK) in Evolution: The Importance of a Professional Development Program at the University and at the Schools

Claudia Vergara, Universtity Alberto Hurtado
Paulina Bravo González, Pontificia Universidad Católica de Valparaíso
Hernan Cofre, Pontificia Universidad Católica de Valparaíso

ABSTRACT:
Teaching and learning evolution is a very important topics in science education. However there exist very few researches about how develop the teachers' Pedagogical Content Knowledge (PCK) in this issue. The following paper describes the development of PCK in evolutionary theory (ET) in three biology teachers. These teachers were a subset of sixteen biology teachers that participated in a professional development program focus in nature of science and ET that included 60 hours of work at the university (biology teaching methods class, nature of science and scientific inquiry class, training in evolution and teaching evolution, microteaching sesión) and a coaching period in the school including workshop of planning lesson together, recording lessons of NOS and evolution, interviews and writing reflections of lessons. The results show that teachers modify their PCK in ET to recognize different teaching strategies and new preconceptions for that content They also feel more prepared to teach ET but notice that they feel insecure in some aspects such as assessment of learning of this subject. Finally, teachers recognize that this type of professional development program provided them with the understanding of the ET, also allowed them to implement new ways of teaching ET with their students.

Science Teachers' Familiarity with, Interest in and Conceptual Knowledge of Basic Microbiology Concepts

Frackson Mumba, University of Virginia
Nastassia Jones, Philander Smith College
Vivien M. Chabalengula, University of Virginia

ABSTRACT:
The purpose of this study was to assess teachers' levels of familiarity with, interest in, and understanding of selected basic microbiology concepts foundational to understanding biology. A sample comprised 62 in-service elementary, middle and high school teachers from several school districts in the Midwestern United States. Data was collected through a three-section instrument in which teachers were asked to indicate their familiarity with and interest in learning more about fifteen basic microbiology concepts. Teachers were also asked to define the fifteen microbiology concepts. Results show that teachers' self-reported high levels of familiarity with the microbiology concepts did not match with their actual knowledge of the concepts. Most teachers provided incorrect or partially correct definitions of the microbiology concepts. However, teachers' high levels of interest in learning more about the microbiology concepts suggested their willingness to address their low knowledge of the concepts. Elementary grade teachers expressed the lowest levels of familiarity with, interest in, and conceptual knowledge of microbiology concepts followed by middle and high school teachers. These results have implications on science teacher preparation, teaching and learning of microbiology concepts in schools.

Mapping out the Growing Trends and the Crucial Structures of Biology Teachers' Pedagogical Content Knowledge

Chunlei Zhang, East China Normal Universtiy
Enshan Liu, Beijing Normal University

ABSTRACT:
Researchers have studied Pedagogical Content Knowledge (PCK) for almost 30 years since Shulman first proposed this concept (1986). Many teacher knowledge domains have been identified and various PCK models are created and discussed. Few papers highlight what knowledge structure is more crucial for teachers. This

study basically employed the instrument Content Representation (developed by Loughran et. al., 2001) to capture the topic-specific PCK of high school biology teachers. The responses were coded into concept maps and analyzed using statistics software SPSS. Result showed that teachers with high professional title and more teaching experience tend to have more developed PCK with significantly more nodes and links in their coding concept maps, and teachers with better awards have significantly more links than other groups. Different teacher groups such as experienced or high-titled have special links in their maps which imply that they own special PCK structures that distinguish themselves from other teachers. Four types of PCK networks were identified and descried, which imply that different growth path may exit for biology teachers' PCK development. This study also provides a promising way to visualize and analyze PCK by coding qualitative data into concept maps. Implications for teacher education and teacher learning are discussed.

Examining Teachers' Curriculum Designs and their Evolved PCK in the Context of Modeling-Centered Inquiry
Marios Papaevripidou, University of Cyprus
Zacharias C. Zacharia, University of Cyprus
ABSTRACT:
The purpose of this study was to identify and describe the characteristics of teachers' designed Modeling-Centered Inquiry (MCI) curriculum materials and use teachers' curriculum materials as a lens to examine aspects of their evolved pedagogical content knowledge (PCK) for MCI. The participants were twenty beginning science teachers enrolled in a professional development course that was organized in phases. During Phase 1, the teachers were engaged in multiple cycles of model development and deployment of collision phenomena. During Phase 2, the teachers were provided with theoretical frameworks on MCI and asked to reflect on their understandings of MCI. During Phase 3, the teachers were asked to re-design an existing unit from their science curriculum through adapting the MCI approach. The data sources involved teachers' curriculum materials that were analyzed with the use of grounded theory methodology. The analysis revealed seven critical standpoints through which the characteristics of teachers' curriculum materials were clustered along three levels of increased sophistication. Additionally, three different PCK for MCI teacher profiles emerged that provide insights of how teachers' PCK for MCI has been influenced by the course, and also demonstrate the diverse ways that the underlying principles of the MCI approach were conceptualized by the participants.

Strand 10: Curriculum, Evaluation, and Assessment
Argumentation
1:00pm - 2:30pm, Grand B
Presider: Molly Stuhlsatz, BSCS

DiALoG: A Practical Instrument Designed for the Assessment of Verbal Classroom Argumentation in Real Time
J. Bryan Henderson, Arizona State University
Claire E. Fenton, University of California - Berkeley
Katherine L. McNeill, Boston College
P. David Pearson, University of California - Berkeley
Jacqueline Barber, University of California - Berkeley
ABSTRACT:
Teachers are privy to relatively few valid and reliable assessments for speaking and listening, and next to none that focus on scientific argumentation. The objective of this study was to develop a simple instrument that can nonetheless overcome some of the challenges in assessing the quality of verbal argumentation at the group level of analysis. In addition to high inter-rater reliability ($R2 = .933$) for the total scores allocated by each of two raters to $n = 28$ videotaped episodes of classroom group argumentation, eight weeks later the same video

episodes were scored in the exact same order by the same two raters, yielding high test-retest reliability as well ($r(28) = .966$, $p < .001$). Exploratory factor analysis permitted consolidation of items with high levels of shared variance into a more parsimonious set of eight items spanning two primary dimensions that collectively accounted for more than 85% of the total variance in scores. Together, these two dimensions on the DiALoG instrument offer teachers a verbal assessment that spans multiple unique aspects of verbal argumentation. Yet since a group level of analysis means teachers do not have to focus on individual utterances, DiALoG's eight-question assessment has potential for practical classroom use.

Construction of Rubrics to Evaluate Content in Students' Scientific Explanation Using Computerized Text Analysis

Kevin C. Haudek, Michigan State University
Michele M. Weston, Michigan State University
Rosa Moscarella, Michigan State University
John Merrill, Michigan State University
Mark Urban-Lurain, Michigan State University

ABSTRACT:
A major challenge to using constructed response items in high enrollment undergraduate STEM courses is the ability to evaluate the scientific content of student explanations, which can be aided using evaluation rubrics. However, rubric development is often an iterative process and requires subject expertise and the ability to identify emerging themes from student writing. Here, we report on leveraging the results of lexical and statistical analysis of students' writing to develop a rubric to evaluate scientific content contained in student responses to an acid/base chemistry question. Lexical analysis was used to identify and categorize relevant content in student responses. These lexical categories were used as variables in K-means clustering, which resulted in three content clusters. Each cluster was defined by categories that included relevant subject content to acid/base chemistry. These clusters were used as the basis of an initial analytic rubric. Two raters applied this rubric to a subset of student responses and after revisions to the rubric and scoring iterations, achieved good levels of inter-rater reliability (>0.8 Cohen's kappa) on five rubric criteria. We believe this methodology may be broadly useful for reducing the effort necessary for evaluation rubric creation.

Development of Framework for Assessing the Quality of Socioscientific Argumentation

Yeonjoo Ko, Ewha Womans University
YunHee CHOI, soongmoon middle school
Hyunju Lee, Ewha Womans University

ABSTRACT:
In this study, we aimed to develop a framework for assessing the quality of socioscientific argumentation. First, we examined the achievements and limitations of previous research on argumentation assessment to seek for a method to analyze comprehensively the quality of dialogic argumentation. Second, we collected and analyzed the data on student dialogic argumentation in order to refine the rubric and distinct each level of the rubrics. Twenty 9th grade students who attended in SSI program participated, and had group discussion on three SSIs. As a result, we developed assessment framework which evaluates the quality of the structure of dialogic argumentation as well as level of the understanding of natures of SSIs reasoning. The framework indicates active and dynamic discourse moves and the level of understanding natures of SSIs such as multiple perspectives, complexity, and moral sensitivity in their group argumentation. This assessment framework for socioscientific argumentation may be used to evaluate the improvement of argumentation skills and decision-making process.

Measuring High School Students' Ability to Construct and Critique Arguments in Ecology

Anna MacPherson, Stanford University

ABSTRACT:

Scientific argumentation is at the center of a set of eight practices described by the new Framework for K-12 Science Learning, reflecting its central role in the development and refinement of ideas in science. An essential precursor to successful integration of argumentation into science classrooms is the development of assessments. This paper describes the development of a new instrument to assess high school students' ability to construct and critique arguments in ecology. Preliminary analysis indicated a high degree of construct validity—high school students engaged in construction and critique of scientific arguments while completing the assessment tasks. Rasch analysis indicated that items spanned a range of difficulty, The analysis also highlighted the importance of the context for argumentation—item bundles situated in unfamiliar contexts were, on average, more difficult than those situated in familiar contexts. An important product of this work is a field-tested instrument, suitable for use by researchers and practitioners. In addition, the work provides insights into the process of developing such instruments, which will inform the development of future assessments designed to measure students' progress with scientific practices.

Strand 11: Cultural, Social, and Gender Issues
Strand Sponsored Symposium - Examining NGSS Practices through Cultural, Social, and Gender Perspectives
1:00pm - 2:30pm, Grand Suite 3
Presenters:
Michelle A. Fleming, Wright State University
Lisa Kenyon, Wright State University
Bhaskar Upadhyay, University of Minnesota
Brian Scott Fortney, Texas Tech University
Reynee Kachur, University of Wisconsin Oshkosh
Oliver Schinkten, Oshkosh Area School District Oshkosh, Wisconsin
Angela Chapman, University of Texas - Pan American
Anna R. Lewis, University of South Florida
Samantha M Baker, Wright State University
Kyle J. Phelps, Wright State University
ABSTRACT:
How is the implementation of the Next Generation Science Standards (NGSS) scientific and engineering practices impacting classroom culture and engagement? Coinciding with the theme of the conference, what does it mean to teach the reforms in light of cultural, social, and gender issues? This interactive symposium intends to eclectically and holistically examine connections between social, cultural, and gender identities and engagement in the NGSS practices. Looking both within and across multiple studies, contexts, and methodologies, researchers will disseminate presentations that contribute to a more systematic conversation around the phenomena of the NGSS implementation, practices, and classroom culture. Changes in classroom cultural practices and the engagement of practices will be examined. Attendees will be encouraged to interact with individual researchers and with the whole group to discuss future implications for research, professional, and educational needs and interests.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set - De/Reconstructing (Re)evolutionary and Socially Just Places of Learning in Formal **Science Classrooms**
1:00pm - 2:30pm, Grand A
Discussants:
Felicia Moore Mensah, Columbia University
Alberto Rodriguez, Purdue University

ABSTRACT:
Our goal with this related paper set is to present 4 unique approaches to transformative and liberatory science education from our work in secondary science classrooms as science teachers, science teacher leaders/teacher educators, and science education scholar-activists. The first paper offers a framework for rethinking school science for critical literacy. The second paper illustrates the complexities and opportunities of teaching an Advanced Placement chemistry course deeply informed by social justice theories of education. In the third paper, the authors/presenters share results from a participatory research project designed to prepare underserved students for youth leadership and community engagement through science education. The author of the fourth paper describes her experiences as science instructional leader and facilitator of a teacher inquiry group in which she and three early career teachers--all Women of Color--used a Freirean approach to science curriculum development. Each of the papers gives context to this (re)evolutionary work as it stands, looks, and feels, "on the ground." Our experiences and results reveal how we have overcome, struggled, navigated, and meditated on this social justice/science "project" that is central to our work and identity as scholars—particularly as scholars co-participating in the plight of marginalized students, families, and communities toward more equitable and just educational opportunities.

Promoting Youth Voice and Social Change in Science through Participatory Research: Challenges and Opportunities of an Emerging University-School Partnership
Sara E. Tolbert, University of Arizona
Nicole Snook, Western Institute for Leadership Development
Corey Knox, University of Arizona

Catalyst for (re)evolution? Critical and Culturally Relevant Pedagogy in Secondary Chemistry
Daniel Morales-Doyle, University of Illinois at Chicago

Introducing the "P5": An Inclusive and Transformative Framework for Science Literacy in Diverse Classrooms
Salina T. Gray, Stanford University

Supporting Teacher Inquiry to Construct Critical Science Pedagogies with Marginalized Urban Youth
Alejandra Frausto, Rudy Lozano Leadership AcademyAcademy

Strand 11: Cultural, Social, and Gender Issues
Symposium - Reorganizing Contexts of Practice for Equitable Science Learning
1:00pm - 2:30pm, Gold Coast
Presiders:
Shelley Stromholt, University of Washington
Suzanne M. Perin, University of Washington
Discussant:
William R. Penuel, University of Colorado Boulder
Presenters:
Suzanne M Perin, University of Washington
Shelley Stromholt, University of Washington
Tammie Visintainer, University of California Berkeley
Ananda M. Marin, Northwestern University
Veronica Cassone McGowan, University of Washington
Carrie T. Tzou, University of Washington Bothell
Heather Toomey Zimmerman, Penn State University
ABSTRACT:

The purpose of this symposium is to explore how researchers and practitioners have focused on the practices of science in a range of settings as a means to broaden participation in science education. The Framework for K-12 Science Education (NRC, 2012) and the Next Generation Science Standards (NGSS, 2013) represent a shift to focus on the intersection of disciplinary core ideas in the context of practice-focused curricula and instruction. As we seek to broaden participation in science learning, this perspective provides a means to support all learners by providing access to sophisticated forms of disciplinary practice. However, while science as practice foregrounds the mature disciplinary practices of professionals, serving as a design for curriculum and assessment in schools, the studies presented here also attend to the ways in which science in practice foregrounds how science and engineering are developed through people's contributions in everyday social practices (Penuel, in press). This collection of studies presents a focus on the production of science and engineering within the social practices of diverse communities, in order to design and support activities that reorganize contexts of practice and therefore, the ways that people imagine themselves and their futures.

Strand 13: History, Philosophy, and Sociology of Science
Science Literacy K-12 Education
1:00pm - 2:30pm, Columbus AB
Presider: Jason R. Wiles, Syracuse University

South African High School Learners' Views about Scientific Inquiry
Estelle Gaigher, Universityof Pretoria, South Africa
Norman G. Lederman, Illinois Institute of Technology
Judith S. Lederman, Illinois Institute of Technology
ABSTRACT:
This paper presents results of a study about South African learners' knowledge about scientific inquiry using the Views About Scientific Inquiry (VASI) questionnaire. The sample consisted of 105 grade 11 learners from 7 schools across the socio-economic spectrum in a South African city. Results showed that the learners held more informed views than that reported in previous international studies. The results are discussed in terms of the Revised National Curriculum Statement (RNCS) that was taught from 2003 to 2010 in South African schools. This curriculum was founded on outcomes based principles, valuing process skills rather than content. The study found that examples provided in the RNCS document correspond closely to the aspects of inquiry as described by the National Research Council (NRC). It is argued that the RNCS contributed to the more informed views about inquiry found amongst South African learners in this study.

A Comparative Study of Students' Epistemological Beliefs about Biology, Chemistry and Physics
Sarah Halwany, Ontario Institute for Studies in Education (OISE) University of Toronto
Saouma B. BouJaoude, American University of Beirut
ABSTRACT:
The purpose of this research is to explore whether students exhibit domain-specific epistemological beliefs about biology, chemistry and physics. Evidence for domain-specificity stems from comparing students' epistemological beliefs on disciplines that can be clearly distinguished as hard-soft (Biglan, 1973a). However, no study examined students' epistemological beliefs about three commonly-taught-science disciplines in schools that can be more difficult to distinguish namely biology, chemistry and physics. Being specifically sensitive to the context and discipline, Hofer's (2000) framework is adopted in the present study to assess sophomore university science students' epistemological beliefs about these three disciplines in a Middle Eastern Country (MEC). Thirty-two students rated items on three versions of a questionnaire assessing their epistemological beliefs on biology, chemistry and physics. Out of this sample, twenty students were selected for a semi-structured interview. For each discipline, students' epistemological beliefs were analyzed and compared across the three sciences on each of the four epistemological dimensions advocated by Hofer (2000):

certainty/simplicity of knowledge, source of knowledge, justification of knowledge and attainability of truth. Results revealed that students hold, to varying degrees, differing epistemological beliefs about the three sciences for each epistemological dimension. Recommendations for future research, curricular reforms and science instruction are discussed.

What do Scientists do? Students` Concepts about Scientists` Work and its Relation to Career Aspirations

Carolin Frank, Leibniz Institute (Leibniz-Institut für die Pädagogik der Naturwissenschaften und Mathematik)
Manuela Niethammer, University of Technology Dresden

ABSTRACT:

To foster interest in science-related careers an effective approach for shaping job-oriented teaching and learning processes in science lessons is necessary. As precondition empirical evidence regarding the characteristics of students which have an influence on their career aspirations is needed. It is well known that interest in science and performance related variables like science self-concept and achievement scores in science are important for the development of science-related career aspirations. Although vocational choice theories state that the knowledge about a profession has an impact on vocational choice, there is no empirical evidence. The aim of the presented project is to describe students` concepts about the work of scientists and to investigate if the concept is related to science-related career aspirations. The concept about the work of scientists, interest in science, science-self-concept and achievement scores in science and mathematics were surveyed with a questionnaire. This instrument was administered to a sample of N=434 10th-grade and 11th-grade students. The findings suggest that certain aspects of the concept about scientists work are related to science career aspiration in addition to interest and performance variables.

GAENE (v.2.0): Further refinement of the Generalized Acceptance of EvoltioN Evaluation (GAENE)

Mike U. Smith, Mercer University School of Medicine
Scott W. Snyder, University of Alabama at Birmingham

ABSTRACT:

The present study reports the further development of the Generalized Acceptance of EvoltioN Evaluation (GAENE, pronounced “gene”). GAENE (v.1.0) was based on extensive student interviews and pretesting of the initial items followed by quantitative validity testing (Lawshe, 1975) that employed two rounds of expert review, then by reliability testing of over 600 high school (HS) and post-secondary (PS) students. Data analysis (previously reported) revealed high reliability (Cronbach alphaHS = 0.940; Cronbach alphaPS = 0.948; Cronbach alpha combined = 0.945). Principal components analysis suggested that the GAENE (v.1.0) measures a single factor. Rasch analysis, however, showed that some items were redundant and were removed. Rasch analysis also suggested the need for additional items to extend the range of respondent “ability” to agree or disagree. New items were generated and submitted to expert review and Lawshe validation. The resulting 14 total-item GAENE (v.2.0) was submitted to 529 college/university students as well as a group of high school students for final reliability testing. Pending the completion of the high school data collection and PCA and Rasch analysis, the psychometric qualities of the GAENE (v.2.0) will be presented.

The Past, Present, and Future of Learning Gardens for Scientific Literacy

Carrie A. Strohl, University of California

ABSTRACT:

Recently, increased attention to sustainable food sourcing, healthier eating, better land management and “back-to-basics” movements (e.g., Slow Food, Locavore) has spurred a resurgence of interest in school and community gardens. Seen as a valuable tool for promoting awareness of societal issues such as overreliance on fossil fuels, obesity and disease, or the misuse of chemical fertilizers and pesticides, gardens have been leveraged equally in formal and informal arenas while farm-to-school, garden-to-table, dirt-to-dine and backyard-to-belly initiatives take hold all over the United States. Although anecdotal evidence abounds, empirical evidence for learning gardens remains sparse, especially with respect to scientific literacy. This

theoretical paper applies a synthesized definition of scientific literacy to learning garden research. In the first section, I trace key historical developments in science education and garden-based learning (GBL) to situate the parallel relationship between curricular science reforms and the use of gardens as instructional tools. In the second section, I interpret previously reviewed empirical GBL literature through a four-part lens of scientific literacy. Finally, I articulate methodological considerations for GBL implementation and research as a means for improving scientific literacy amidst the most recent vision for science education (NRC, 2012).

Strand 15: Policy
Policies and Political Contexts in an Era of Data-driven Decision-making
1:00pm - 2:30pm, Columbus CD
Presider: Carla C. Johnson, PurduePurdue University

Assessing the Impact of a Statewide STEM Strategic Plan on Community STEM Awareness over Time
Toni A. Sondergeld, Bowling Green State University
Carla C. Johnson, Purdue University
ABSTRACT:
Despite monetary and educational investments in STEM being at record high levels, little attention has been devoted to generating a common understanding of STEM. In addition, working with business, K-12 schools, and/or institutions of higher education to establish a grass-roots effort to help community members understand the importance of STEM regarding the future prosperity of the U.S. in general, and specifically the preparedness of children for careers of now and the future, has been nonexistent. The purpose of our study is to assess the impact of a statewide STEM professional development program implemented for two years on STEM awareness over time among various community stakeholders (i.e., K12 Teachers, Higher Education Faculty, Business Members). STEM awareness and beliefs about STEM engagement, resources, student preparation, and careers all improved over time for all groups. However, Business Members had the greatest growth over time and held significantly higher awareness compared to the other groups in most areas. Our findings suggest that a statewide STEM partnership/network model is a viable option for growing collective impact and sustainability of STEM K12 education.

Why Science Education Should Care about the Educational Data Movement
Kathryn Kirchgasler, University of Wisconsin-Madison
Melissa Braaten, University of Wisconsin-Madison
Sadie Barocas, University of Wisconsin-Madison
Christopher Bradford, University of Wisconsin-Madison
ABSTRACT:
Mounting emphasis on “data-driven” instruction has emerged in connection to standards-based, and test-based accountability policies in schools. This emphasis – along with a host of tools, books, and a new language of practice – is what Piety (2013) refers to as the educational data movement. Because most “data” and accountability policies have not been directly focused on science teaching and learning, this movement has largely bypassed science education. However, this may change as growing interest in STEM education converges with the release of the NGSS and forthcoming assessments. What lessons can the NARST community learn that might help as we make use of standards and performance assessments within the context of the educational data movement? During 2013-2014, we were embedded observers in 3 secondary schools. We conducted: 290 classroom observations; 260 post-observation debriefings; 42 teacher interviews; and 280 hours of meeting observations. This ethnographic study analyzes: 1) how science teachers obtain, analyze, and use information about students; 2) how they make sense of contextual discourses about data use within across settings. We hope that our findings will inform NARST members working proactively to shape policy and teacher practice as NGSS and related assessments become prevalent in schools.

Revisiting the Coleman Report: Exploring School Effects on Scientific Literacy in PISA 2012 using Hierarchical Linear Modeling

Hye Sun You, The University of Texas at Austin
Cesar Delgado, University Of Texas at Austin

ABSTRACT:
Inequality in achievement remains a persistent challenge for U.S. education. The influential Coleman report (1966) placed the source of variation in achievement in student demographic characteristics, using single-level techniques. This study revisits the same question, using the large, nationally representative 2012 PISA US data set and a multi-level statistical technique: hierarchical linear modeling. The study focuses on schools, and how characteristics of U.S. schools influence variation in students' science achievement. After incorporating the school characteristics of mean socioeconomic cultural status (ESCS), school type, size, and quality of resources in the final model, we found that a good deal of variability across schools was observed; in contrast to Coleman's findings, school variation was found to have more impact on students' science achievement than students' characteristics. School mean ESCS and school type were statistically significant predictors of mean science scores. Public schools were found to outperform private schools after controlling for school characteristics. The findings from this study demonstrate distinct school differences in the relationships between mean ESCS, school type and science achievement. This study makes a contribution towards a better understanding of school effects in U.S.15-year-olds students' science achievement and points to policy-driven reforms to enhance school equity for all students.

How do Formal Policy and Guiding Documents in Israel Explain Inquiry-based Learning?

Rachel Levin Peled, Technion
Tali Tal, Technion

ABSTRACT:
What is scientific practice? Physicists, chemists and biologists practice science. They conduct experiments and observations, collect data and find out what our universe is made of. What research social-scientists do? What about archeologists? How do they study ancient cultures? Do they employ scientific practice? What evidence do they use? How do they make and support claims? In this study, we aimed to understand how are inquiry and inquiry-based learning viewed and explained in formal documents such as national curriculum documents, chief-superintendents' instructions and the national curricula? We found that in various formal documents, inquiry-based learning is presented in a uniform conventional way. Inquiry is mainly quantitative, experimental activity that examines cause-effect relationships. This is true in science, in social studies in elementary and even kindergarten classes as well as in grades 11-12. Other forms of inquiry such that require drawing evidence based on collecting artifacts and evidence are almost absent. This contradicts updated views of scientific-inquiry. Instead of opening up learning by inquiry to include more genres and approaches and instead of using inquiry-based learning to enhance learning of higher-order thinking skills, inquiry-based learning, as reflected in our analysis seems very closed, limiting, procedural, prescriptive and even un-creative.

Concurrent Session #2
2:45pm – 4:15pm

Administrative Sponsored Symposium
LARIG Admin Session
2:45pm - 4:15pm, Gold Coast
Presenters:
Regina Suriel, Valdosta State University
Rosa Deves, Universidad de Chile
Manuela Welzel-Breuer, University of Heidelberg, Germany (ESERA President)
Blanca Nava, Head of Science Education, Veracruz, Mexico
Daniel Morales-Doyle, Social Justice High School, Chicago, IL
Sara Tolbert, University of Arizona
Ingrid Sanchez Tapia, University of Illinois, Chicago
Kim Gomez, UCLA
Alberto Rodriguez
ABSTRACT:
The 2015 NARST international conference will host LARIG's first panel discussion for understanding the political, cultural and linguistic landscapes of science education for Latinos in national and international contexts. Our goals are to (a) present and provide a forum for critical dialogue on the successes and challenges of Latinos in science education, (b) to map future research on Latino/a science education, and (c) increase networks and research collaborations. We are thrilled to have eight national and international panelists who will discuss their research on the aforementioned themes (see list below). Research themes have also been arranged to address different levels of education, from kindergarten to professoriate. We are inviting community members, teachers and parents to our audience. We plan to host some of our international panelists, and provide transportation for the local community attending the session. We welcome the chance for your sponsorship. We hope you can join us.

Strand 1: Science Learning, Understanding and Conceptual Change
Alternative Conceptions and Competencies
2:45pm - 4:15pm, Grand B
Presider: Vaille Dawson, The University of Western Australia

Investigating the Development of a Learning Progression for Sea Level Rise, a Climate Change Impact
Wayne Breslyn, Montgomery County Public Schools
J. Randy McGinnis, University of Maryland
Emily Hestness, University of Maryland
ABSTRACT:
In this study we present research from an exploratory study on a learning progression for sea level rise (SLR), a consequence of global climate change. Using a draft and hypothetical learning progression for sea level rise that we generated from a comprehensive review of the educational literature on the construct and science reference and policy documents (the AAAS Science Literacy Maps, and the Next Generation Science Standards) we developed an assessment instrument as well as online activity with accompanying instrument on sea level rise as a way to elicit learners' thinking about sea level rise. These instruments were administered to middle school students (N=90) and undergraduate pre-service teachers (N=77). An analysis of the data suggested that our draft and hypothetical learning progression for sea level rise was robust and provided useful information about learner understanding about the construct of sea level rise. The development of a SLR learning progression,

along with the accompanying assessment instruments contributes to research and thinking about learning progressions, in general, and climate change education, in particular.

Process Diagram for Cognitive Requirements and Activities on Solving Tasks in Physics

Bettina R. Kreiter, University of Duisburg-Essen, Germany
Heiko Krabbe, University Duisburg-Essen
Hans Ernst Fischer, University Duisburg-Essen

ABSTRACT:
For upper secondary education, there is still need for an empirically verified competence model that describes physics-specific cognitive requirements. In contrast to test items, German final secondary-school examinations have more than one cognitive requirement per task; they are multiple request tests and cannot be used for diagnosing student performance. In order to make valid statements about the solution requirements needed for each task, a new task profile is needed. The goal of this study is to develop a model that describes pupils' physics-specific cognitive requirements while solving physics tasks in upper secondary education. For this purpose, a literature- and expert-based manual needs to be developed in order to categorize physics-specific cognitive requirements. We performed an exploratory study in which students' (N = 28) cognitive activities can be identified while they solving the tasks by thinking aloud and through guided interviews after solving the tasks.

Identifying and Addressing Students' Alternative Conceptions about the Socioscientific Issue of Climate Change

Vaille Dawson, The University of Western Australia
Leonie J. Rennie, Curtin University

ABSTRACT:
Climate change is one of the most significant science issues facing humanity. Yet, teaching students about climate change is challenging because it is multidisciplinary, controversial and debated in political, social and media forums. Young people need to be equipped with an understanding of climate change science to be able to participate in this discourse. The purpose of this study was to examine high school students' understanding of climate change and the greenhouse effect, in order to identify their alternative conceptions and provide a baseline for more effective teaching. A questionnaire designed to elicit students' understanding and alternative conceptions was completed by 438 Grade 10 students (14 – 16 years-old). A number of alternative conceptions were identified that were related to: nature of greenhouse gases; conflating of the greenhouse effect and the ozone layer; types of radiation; weather and climate; and pollution. These areas can be specifically targeted when teaching the greenhouse effect and climate change. These findings provide science educators and high school science teachers a basis upon which to develop professional development and curriculum resources to improve their students' understanding and decision-making skills about the socioscientific issue, climate change.

Eliciting Students' Tacit Conceptions through Artifact Driven Interviewing

Rory Glass, University at Albany - SUNY

ABSTRACT:
This study examined the emergence of student's alternative conceptions in response to questions about the environment and environmental health during artifact driven interviews. The interviews were conducted using a set of ten photographs purposefully selected to present a variety of landscape representations as described by Romero-Trillo and Espigares' (2013) taxonomy and intended to provide an abstract task for students to reason through using a variety of conceptions. The purpose of the interviews was to ascertain what largely tacit understandings students may draw upon to determine the health of the varied representations. Initial examination of student responses showed that students do utilize a number of tacit understandings when engaging in such abstract tasks. It is suggested that due to the resistance of these alternative conceptions to change it may be of great importance to provide more abstract tasks early on during instruction. This would

allow students to reason with these concepts rather than having them remain hidden, impairing their development of more sophisticated reasoning aligned with standards.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set - Elementary School Engineering: Small Group Interactions and Learning
2:45pm - 4:15pm, Grand Suite 3
ABSTRACT:
The inclusion of engineering content and practices outlined in the Next Generation Science Standards (NGSS Lead States, 2013) has opened up possibilities for new approaches to student learning and evaluation in both science and engineering due to the concentration on project-based activities and engagement in designing technologies. This session consists of four studies that all take place in elementary school classrooms where students learn about engineering by engaging in design activities and NGSS Science and Engineering Practices. With a focus on engineering practices and their enactment, we develop a foundation from which to build on the lack of experience with engineering at the elementary school level toward a vision of successful, productive implementation that supports science learning. Topics in this session include, promoting and nurturing creativity as part of the engineering design process; comparing written with collaboratively enacted design performances; supporting students' engagement in problem-driven activities through an understanding of the epistemic cycles involved in the development of engineering practices; and appreciating the productive aspects of failure as a normative learning experience in engineering. This work serves to inform future curriculum development and implementation, professional development for teachers, and new ways to evaluate student learning.

Cultivating Creative Practices in Elementary Engineering Classrooms
Theresa A. Hegedus, University of North Carolina at Greensboro

Epistemic Cycles in Elementary Engineering: Children's use of Outside Information during Small-group Design and Redesign
William S. Carlsen, Penn State University

Feedback from Failure: Teacher Discourse Moves in Reaction to Students' "Unsuccessful" Elementary Engineering Design Projects
Matthew Johnson, Penn State University

What does a Performance Assessment Capture and what does it Miss? Comparison of Students' Collaborative Engagement in Engineering Design Challenges with their Individual Performances on a Written Assessment
Cathy P. Lachapelle, Museum of Science

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Assessing Young Learner's Science Thinking
2:45pm - 4:15pm, Roosevelt
Presider: Cory T. Forbes, University of Nebraska-LincolnLincoln

How do Science Process Skills look like in Preschools? A First Study of Singaporean Children
Tang Wee Teo, Nanyang Technological University, Singapore
Yaw Kai Yan, Nanyang Technological University, Singapore
Mei Ting Goh, Nanyang Technological University, Singapore
Woei Ling Ong, Ministry of Education, Singapore

ABSTRACT:
This paper describes a first study on early childhood science education in Singapore conducted with the goal to understand how preschool children engage diverse science process skills as they learn science. Twenty-eight preschool children (aged 5 to 6) from two preschool centers participated in four one-hour long science lessons in small groups facilitated by the researchers or preschool teachers. The lessons were videoed and photographed and microanalysis of the process skills were conducted. The findings showed how the preschool children engaged various science process skills including making observations, testing, and application of learning. Their communication skills were limited by the vocabulary they had. Implications for science and preschool educators, and policy makers are drawn from the findings.

Assessing Young Children's Knowledge and Skills in Science
Mary E. Hobbs, Center for STEM Education
Robert Williams, University of Texas
James P. Barufaldi, University of Texas at Austin
ABSTRACT:
This paper describes the development and implementation of hands on assessments by university researchers during a three-year NSF funded study looking at what four year olds know and can do in science. Student data was collected in a total of 48 classrooms in a variety of settings with an emphasis on including classrooms where students were culturally and economically diverse. Over the three years of data collection the total student populations in those combined classrooms exceeded 2,500 children. Twenty-four of the settings were teacher-researcher classrooms while the remainder comprised the comparison group classrooms. (The teacher-researchers collected and reported data on their students while a full time member of our research team assessed students in the comparison group classrooms.) While not themselves a goal of the research, assessments were critical to collecting information about children's knowledge and abilities, and these performance activities and their corresponding rubrics are now important products of the project. Additionally what we learned by administering these assessments to children contributed to our ability to answer our primary research question: What should children know and be able to do in science when they enter Kindergarten?

Elementary Teachers' Use of Life Science Content Knowledge to Inform Formative Assessment Instructional Decisions
Jaime L. Sabel, University of Nebraska-Lincoln
Cory T. Forbes, University of Nebraska-Lincoln
Leslie Flynn, University of Iowa
ABSTRACT:
Elementary students have a variety of preexisting ideas about the natural world that may lack scientific accuracy. Science learning environments should provide opportunities for students to engage with their preexisting ideas to make sense of and refine their understanding of core disciplinary concepts. Teachers can support students' sense-making by engaging and responding to their ideas through high-leverage instructional practices such as formative assessment. However, past research has shown that teachers may not understand formative assessment, how to implement it, or have sufficient content knowledge to use it effectively. Few studies have investigated how teachers gather information they use to modify instruction or how content knowledge plays a role in those decisions. To address these needs, we designed a study embedded in a multi-year professional development program intended to support elementary teachers with learning content knowledge and incorporating formative assessment practices into science instruction. The results we present here emphasize how elementary teachers' content knowledge influences their implementation of formative assessment practices within life science instruction. Study findings contribute to research on teacher education and professional development and have implications for teacher educators and curriculum developers.

The Use of the Science Instructional Log to Understand Elementary Science Instruction

Elizabeth Greive, North Carolina State University
Sarah J. Carrier, North Carolina State University
ABSTRACT:
This work describes the development and use of the Science Instructional Log (SIL) to understand beginning teachers' science instruction in elementary classroom. The SIL was developed to measure science practices outlined in the NGSS. The frequency and type of science instruction in which 77 beginning teachers engaged across the year is described. In order to understand if beginning teachers differ from one another in their instruction, items' intraclass correlations were examined, revealing that beginning teachers differ in the consistency with which they implement high level science practices. These findings support the important work of effectively implementing the NGSS.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
New Perspectives in Models and Modeling
2:45pm - 4:15pm, Grand A
Presider: Li Ke, Michigan State University

Multiple Perspectives on the Use of Models in Biology Lessons
Sonja Werner, LMU Munich
Christian Förtsch, LMU Munich
Lena von Kotzebue, LMU Munich
Birgit Jana Neuhaus, LMU Munich
ABSTRACT:
Features of instructional quality can be measured in different ways: students' perceptions, teachers' perceptions and external, independent observations. Until now, it is not clear which of these measurements work best for domains specific aspects of teaching effectiveness. The aim of this study is to describe the adequate use of models in biology classrooms from all three perspectives and to consider connections between them. Therefore, 32 biology teachers from various secondary schools in Bavaria were videotaped for two neurobiology lessons (N = 64) and completed a questionnaire on how they used models in classroom. Their students (N = 788) completed the same questionnaire. Additionally, an event-based coding-manual was developed based on the questionnaire scales. In 47 of the videotaped 64 lessons we identified models. For all sub-categories of the coding manual we found significant correlations between students' and teachers' perceptions (all $r = .48-.53$, all $p < .05$). Currently, the coding by the external observer is done. At the conference we will compare correlations between students' and teachers' and external observers perceptions to draw conclusions for further coding. The study is part of the project ProwiN financed by the German Ministry of Education (01JH0904).

Comparing Teachers' Implementation of a Lunar Modeling Lesson Using a Modified P-SOP Instrument
Mary Lamar, Eastern Kentucky University
Jennifer A. Wilhelm, University of Kentucky
Merryn Cole, University of Kentucky
ABSTRACT:
This study compares teachers' implementation of a “Moon Finale” lesson using a modified version of the Practices of Science Observation Protocol (P-SOP). This research focuses on two teachers from a larger study of seven teachers each of whom implemented the Realistic Explorations in Astronomical Learning Curriculum. Research questions were: In what ways do teachers who received similar professional development and materials adapt and implement them for their own classrooms? How does this influence student learning? Data sources included videotaped lessons and a Lunar Phases Concept Inventory (LPCI). LPCI results showed that Mr. Land's students gained 37% compared to Ms. Roling's students 17% gain. This study sheds light on possible explanations for the students' gain differences between teachers by analyzing the videos with the

modified P-SOP instrument. In the lesson, students had the opportunity to model in 2- and 3-dimensions the Earth/Moon/Sun system for each of the phases. Teachers implemented the lesson in different ways including the number and kind of questions asked of students as well as and the means by which teachers assisted students in conducting inquiry during this phase modeling lesson. Mr. Land received overall higher ratings on the P-SOP instruments than Ms. Roling.

Talking Modeling: Examining Science Teachers' Modeling-Related Discourse during a Model-Based Inquiry Unit

Ron Gray, Northern Arizona University
Allyson M. Rogan-Klyve, Oregon State University

ABSTRACT:
This exploratory study examines the use of teacher talk around metamodeling knowledge for two secondary science teachers implementing a model-based inquiry instructional unit. While the MBI supported the use of key instructional practices such as making student thinking visible, studying the modeling talk of the teachers revealed the ways in which the teachers used language to frame the modeling work of the classroom. Instances of metamodeling talk were identified in classroom videos and coded using a framework for metamodeling knowledge. Findings showed that the majority (59%) of instances were focused on instructions. Further, of the remaining instances of talk that were identified as focused on metamodeling, many were implicit and varied in accuracy. Such findings suggest a trend of modeling talk aimed at "worksheetizing" the processing of scientific modeling rather than supporting student engagement in the epistemic practice of modeling.

Measuring the Effectiveness of Teaching Interventions Aimed at Supporting Students' Analogical Reasoning around Physical Models

Alison R. Miller, Columbia University
Kim Kastens, Education Development Center, Inc.

ABSTRACT:
Developing robust understandings of Earth System phenomena and processes is important yet challenging for both scientists and students. Building from a three-tiered construct describing students' analogical reasoning between models and the Earth System, we describe our two-year investigation of the ways that 8th grade students learn about and reason about processes of the full-scale Earth System while using dynamic physical models. This analysis includes pre and post test gains in Year 1 and Year 2 along with a description of a three strategy teaching intervention introduced during a professional development workshop in the summer between Year 1 and Year 2. In this study, we present compelling evidence for deliberate consideration of the role of physical models and associated pedagogical strategies in instruction to support effective science learning.

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

Related Paper Set - Next Generation Course Transformation: Four Perspectives

2:45pm - 4:15pm, Columbus KL

Presider: Peter S. Garik, Boston University

ABSTRACT:
Introductory college science courses are critically important in engaging the next generation of STEM majors. Although most students decide to major in a STEM field before they enter college (Maltese and Tai 2011), the experiences students have during college have a strong influence on whether they persist in a STEM major (Huang, Taddese et al. 2000). Traditionally, introductory STEM courses at the undergraduate level are large, lecture-based courses with challenging learning environments (Wood 2009). These courses serve as a barrier, rather than a gateway, to continuing in STEM majors (Tai, Sadler et al. 2005). Professors and policy makers have responded to this dilemma with a number of different learning strategies, yet despite all of these efforts, many science courses at large universities remain unchanged (Wieman, Perkins et al. 2010). This related paper

set investigates the effect of transforming curriculum, classroom dynamics, and learning environments on the learning outcomes and satisfaction for students in large, introductory science courses.

Characterizing Student Interaction in a Learning Assistant Supported Biology Course: The Classroom as a Social Network
Robert M. Talbot, University of Colorado at Denver
Laurel Hartley, University of Colorado at Denver
Laurie Liddick, University of Colorado at Denver
Bryan Shao-Chang Wee, University of Colorado Denver

Teaching Quantum Concepts with an Activity-Based Hybrid Classroom Paradigm
Emily C. Allen, Boston University
Binyomin Abrams, Boston University
Dan Dill, Boston University

Peering through the Gate: The Impact of Near Peer Teachers on Student Grades and Satisfaction in Six Large Introductory Courses
Meredith M. Thompson, Boston University
Peter S. Garik, Boston University

The Learning Assistant Program as a Tool for Course Transformation
Geraldine L. Cochran, Rochester Institute of Technology
Scott V. Franklin, Rochester Institute of Technology

Strand 6: Science Learning in Informal Contexts
Hobbies and Citizen Science
2:45pm - 4:15pm, Water Tower
Presider: Jason Katzmann, University of Wyoming

Examining the Impact of Social Media in a Citizen Science Project
Renee M. Lyons, Clemson University
Michelle P. Cook, Clemson University
David White, Clemson University
Alex Chow, Clemson University
J.C. Chong, Clemson University
Roy Pargas, Clemson University
ABSTRACT:
One approach to improving scientific literacy of non-dominant youth, those traditionally underserved by the education system, is to engage them in informal science experiences (Falk & Dierking, 2010). Despite the growing need for scientific and environmental literacy, the disconnect between the home cultures of many non-dominant youth and school practices leads to negative perceptions of science and low scientific literacy skills (Jolly, 2002). Projects seeking to reach non-dominant groups should draw on the cultural practices of the target group, use everyday language, and communicate through modes culturally accepted by the target group(Jolly, 2002; Nisbet & Scheufele, 2009). This paper examines the impact of social media on who is participating, how long they are participating and what they are learning in a citizen science project. The findings of our study reveal that social media was an effective means to sustain engagement in a citizen science project but was ineffective at changing the demographic make-up of who is participating in the project. A future direction of the

study is to research and choose social media platforms that best reach our target demographic and to utilize the demographic ads offered by those social media platforms (Kaplan & Haenlein, 2010).

Where do they Fit? Astronomy and Birding Hobbyists in the STEM Learning Ecosystem

Elysa N. Corin, North Carolina State University
M. Gail Jones, North Carolina State University
Thomas Andre, Iowa State University
Gina Childers, North Carolina State University
Rebecca Hite, North Carolina State University

ABSTRACT:
Science hobbyists are self-directed learners who engage in lifelong, free-choice learning. Sharing their hobby and contributing to the science learning of others is an important aspect of many hobbyists' hobby involvement. A framework of a STEM learning ecosystem was used to understand hobbyist interactions with the learning institutions and groups in their communities. Interviews were conducted with 107 science hobbyists (58 astronomers and 49 birders). The analyses showed that the science hobbyists in our sample are an active component of the STEM learning ecosystem. Formal learning institutions (i.e. universities), informal learning institutions (i.e. museums, parks), and other community groups (i.e. hobby clubs) create important learning opportunities for hobbyists. Many hobbyists also interacted with these organizations in the capacity of educators, and engaged in outreach to scout groups and K-12 schools about their hobby interest. Differences in interactions between astronomers and birders with these organizations and groups are described. This study demonstrates the potential for future collaboration between hobbyists and other sectors of the STEM ecosystem. The results of this study show the extent and depth of engagement that hobbyists have as both learners and teachers of STEM.

Participant Motivations, Goals, and Learning in a Large-Scale Informal Geoscience Education Program

Sharon Locke, Southern Illinois University Edwardsville
Georgia Bracey, Southern Illinois University Edwardsville
Rosey Morr, Southern Illinois University Edwardsville

ABSTRACT:
This mixed-methods study explored what motivates participation in the EarthCache program and what participants view to be the program's benefits for science learning. EarthCache is an informal educational experience that extends the activity of geocaching to include learning something about Earth's geologic features and processes. More than four million people have EarthCached since 2004, but little is known about their individual experiences and the potential of the program to increase content knowledge, develop interest, and promote deep engagement in science. For this study, over 400 people responded to an online survey that included questions about level and frequency of participation, motivation, goals, barriers, and perceived learning. Interviews of 56 EarthCachers with a range of experience levels supported and enriched the survey data. Among survey respondents, the two strongest motivators for EarthCaching were the opportunity to see rare and unusual Earth features and to see something that is new to them. This "Novelty" theme was also evident in the qualitative data. Survey respondents most frequently reported learning about Earth's processes, composition, and history. For some individuals, EarthCaching is a sustained "science hobby" that provides engagement with geoscience content and scientific practices and taps into personal curiosity and interest in the Earth.

Examining Science Identity in the Context of a Citizen Science Program in a Leisure Setting

Sue Magdziarz, John G. Shedd Aquarium
James F. Kisiel, California State University, Long Beach

ABSTRACT:

This research project examined how adults in Southern California utilized a Dolphin Observation Citizen Science Kit in a leisure setting, which is not usually associated with offering science education programs. The study set out to explore whether people with a range of science identities (defined as interest in and comfort with science) would choose to participate in the program and the extent to which they would use the kit. The findings showed that people who chose to participate in the program had a range of science identities. Although it is not surprising that people with a strong science identity would use a citizen science kit, this study showed that they were interested in reinforcing that identity even in a leisure setting. The findings also indicated that adults with a weak science identity used the kit in a similar fashion (e.g., used binoculars, used the written materials in the kit, etc.) as adults with a strong science identity. This is promising because it indicates that recreational settings could potentially be locations that reach people who do not typically visit science centers and museums.

Strand 7: Pre-service Science Teacher Education
Teachers' Abilities, Reasoning, and Argumentation
2:45pm - 4:15pm, Comiskey
Presider: Kemal Izci, Necmettin Erbakan University

Do Pre-Service Elementary Teachers Learn to Make Evidence-Based Claims When Doing Inquiry-based Labs?
Rebekka Darner Gougis, Illinois State University
Janet F. Stomberg, Illinois State University
Elizabeth S. Quinn, Illinois State University
ABSTRACT:
Incorporation of scientific argumentation in the Next Generation Science Standards (NGSS) has highlighted an ongoing challenge to teacher educators – to provide pre-service teachers (PSTs) experiences that compel them to make evidence-based claims. The purpose of this study is to compare the type of evidence (i.e., empirical, authoritative, anecdotal) that PSTs use to support their claims after different types of lab experiences. Specifically, we compare claims made after an inquiry-based lab with claims made after a hands-on but non-inquiry lab. Results inform our selection of lab experiences for PSTs and offer insight into various strategies that will effectively prepare PSTs for implementation of the NGSS.

Effectiveness of Case-Based Learning Laboratory Instruction and Scientific Reasoning Ability on Science Preservice Teachers' Understanding of Some Science Concepts
Aylin Cam, Mugla Sitki Kocman University
Yusuf Sulun, Mugla University
Gökhan Güven, Mugla Sitki Koçman University
ABSTRACT:
The purpose of the study was to investigate the effectiveness of case-based learning laboratory over traditional laboratory instruction on freshman science preservice teachers' understanding of particulate nature of matter, chemical and physical change, concentration, stoichiometry, reaction rate and factors effecting reaction rate and chemical equilibrium. The participant consisted of 37 freshman science preservice teachers from two intact classes of a rural educational faculty which were instructed by the same instructor. Each teaching method was randomly assigned to each class. The experimental group received case-based learning laboratory and the control group received traditional laboratory instruction. In experimental group, life cases were presented with small group format; in control group, lecturing and discussion was carried out. The results showed that there was no significant difference between the experimental and control group with respect to their understanding of these chemistry concepts. However; regarding scientific reasoning ability level, there was a significant differences among the understanding these chemistry topics of concrete, formal and post-formal reasoners, in favor of formal reasoners. Also, SPTs' scientific reasoning ability levels were affected equally both case based

learning laboratory and traditional laboratory instruction. Case-based learning laboratory instruction should be implemented in order to remediate misconceptions when used properly.

Cultivating Preservice Elementary Teachers' Ability to Learn How to Teach Science from Curriculum Materials

Etsuji Yamaguchi, Kobe University
Kyoko Kanbayashi, Kobe University

ABSTRACT:
The challenges faced by the elementary science teachers have gained prominent attention. Teacher educators recognize that one of issues is to help them be well-started beginners. Additionally, they recognize that curriculum materials are one of powerful tools for elementary science teacher education. The purpose of this study is to develop and evaluation of the teacher education program for cultivating preservice elementary teachers' ability to learn how to teach science from curriculum materials. We based on Design Capacity for Enactment framework to identify teachers' proficiency , and Teachers' Professional Vision framework to set design conjectures for developing program. Participants were a total of eighty-four Japanese preservice elementary teachers of a national university. In the program, we engage the preservice teachers in considering and learning about both content-oriented and inquiry-oriented science teaching through designing science lessons using curriculum materials. We conducted pre and post test whose environment that teachers can interact with curriculum materials. It is clarified that preservice teachers' ability to learn from curriculum materials was cultivated through our teacher education program. They have acquired ability to learn more specific knowledge relating teaching for specific topic. Finally, we discussed implications for theoretical frameworks and preservice science teacher education.

Enhancing Pre-service Science Teachers' Self-efficacy To Teach Science through Argumentation

Mehmet Aydeniz, The University of Tennessee
Zehra Ozdilek, Uludag University

ABSTRACT:
The purpose of this study was to explore the impact of mastery experiences and reflection on pre-service science teachers' self-efficacy to teach science through argumentation. Forty pre-service science teachers in their final semester of schooling participated in an intervention that lasted for eleven weeks. The participants engaged in argument construction, evaluation and critique, taught three argumentation lessons, engaged in peer observation of teaching, and reflection on their teaching skills. Data were collected through Argumentation Self-Efficacy Scale and an open-ended questionnaire. The results show that the intervention had a significantly positive effect on pre-service teachers' self-efficacy. Despite this reported self-efficacy, participants experienced significant challenges in guiding their students to construct scientific arguments and assessing the arguments developed by their students. Discussion focuses on implications for professional development of pre-service and in-service science teachers.

Strand 7: Pre-service Science Teacher Education
Teachers' Knowledge and Technology Use
2:45pm - 4:15pm, Randolph
Presider: Mary K. Nyaema, University of Iowa

Using PeerWise Online Collaborative Tool to Improve Physics Teacher-Candidates' Questioning Skills

Marina Milner-Bolotin, University of British Columbia
Heather A. Fisher, The University of British Columbia
Alexandra L. MacDonald, The University of British Columbia

ABSTRACT:

Ability to develop, evaluate and ask conceptual questions is a key skill in shifting science learning from factual memorization to conceptual understanding. This presents significant challenges to science teacher education programs. Many pedagogical approaches have been proposed to facilitate this shift. One such pedagogy is Peer Instruction, which hinges on teachers' abilities to ask powerful questions that challenge learners' prior knowledge and facilitate concepts' application to novel contexts. PeerWise, an online collaborative platform where students can author, evaluate, rate, and comment on peer-authored multiple-choice questions, was used to facilitate the development of their questioning skills. This paper reports on a pilot study in a physics methods course where Peer Instruction was used as a central pedagogical approach, focusing on developing teacher-candidates' questioning skills. In addition, teacher-candidates used PeerWise to submit conceptual questions, comment on peer questions, and receive feedback from instructors and peers. At two time points (outset and conclusion of the course), teacher-candidates' questions were evaluated for conceptual difficulty using Bloom's Taxonomy, while comments were rated on how teacher-candidates articulated their Pedagogical Content Knowledge. Questions' conceptual difficulty increased, while comment quality unchanged throughout the course. Implications of these findings and future directions for this research are considered.

Modeling Elementary Science Teachers' TPACK

Sevgi Aydin, Yuzuncu Yil University
Sevda Yerdelen-Damar, Yuzuncu Yil University
Yezdan Boz, Middle East Technical University

ABSTRACT:

For the effective technology integration, TPACK (Technological pedagogical content knowledge) framework has been suggested by Mishra and Koehler (2006). However, nature of factor structure of TPACK has not been explained. This study aims to both validate factor structure of TPACK and reveal the interrelationships among components. We tested a structural equation model (SEM) constructed based on TPACK literature with LISREL 8.8. The study included 665 senior elementary pre-service science teachers (467 Females, 198 Males) from 7 colleges. The model had acceptable fit ($\chi 2(878, N = 665) = 2546.55$, $\chi 2/df = 2.90$, CFI = .99, RMSEA = .05, SRMR = .05). In the model, direct relations of core components (e.g., PK) to TPACK were not proposed. Instead, indirect relations through interaction components (e.g., PCK) were hypothesized. All hypothesized relations got significant path coefficients. Second, indirect relations of CK, TK, and PK were also significant. When sizes of indirect effects are compared, relation of PK to TPACK through PCK and TPK is greater than that of CK through PCK and TCK and TK through TCK and TPK. Regarding amounts of explained variances on all dependent constructs (R2), CK, PK, TK, PCK, TCK and TPK explained 87% of the variance of TPACK.

Modeling Relations of Attitudes towards Technology Use, Technology Competencies, Ownership, and Experiences to TPACK-Self Efficacy

Sevda Yerdelen Damar, Yüzüncü Yil University
Sevgi Aydin, Yuzuncu Yil University
Yezdan Boz, Middle East Technical University

ABSTRACT:

This study modeled the relations of attitudes towards technology use, technology ownership, technology competency, and experience to self-efficacy of technological pedagogical content knowledge (TPACK-S). The study also investigated inter-relations among attitudes towards technology use, technology ownership, technology competency, and experience The participants of the study were 665 elementary pre-service science teachers (467 Females, 198 Males) from 7 colleges. The proposed model designed based on educational technology literature was tested using structural equation modeling. The results indicated that technology competency and experience mediated the relation of technology ownership to TPACK- self efficacy. The direct relation of technology ownership to TPACK- self efficacy was insignificant while indirect relation through technology competency and experience was significant. This implies that simply having technology is not enough for higher TPACK- self efficacy, it is also vital to have adequate level of technology competency and experience. The results also showed there were significant direct effects of attitude towards technology use, technology competency, and experience on TPACK-self efficacy.

Preservice Science Teachers' Capacity to Plan Using Technology in an Integrated Teacher Preparation Program

Aaron Kessler, University of Pittsburgh

ABSTRACT:
This study explores and describes preservice science teachers (PST) ability to incorporate technological resources into their planning in ways that support engaging secondary science students in the science and engineering practices outlined in the Next Generation Science Standards document. Results from a pre-post lesson plan analysis suggest that PSTs are able to develop the ability to plan using technology after instructional interventions in their teaching pedagogy courses.

Strand 8: In-service Science Teacher Education
Pathways to Professional Growth for Inservice Teachers
2:45pm - 4:15pm, Columbus IJ
Presider: Andri Christodoulou, University of Southampton

Professional Identity Interactions and Triggers for Change: A Multiple Case Study of Teachers' Responses to Professional Development

Stephanie J. Hathcock, Oklahoma State University
Joanna K. Garner, Old Dominion University
Daniel L. Dickerson, Old Dominion University
Avi Kaplan, Temple University
Petros Katsioloudis, Old Dominion University

ABSTRACT:
Although science teachers regularly participate in PD experiences involving reform-based practices, even our best teachers struggle to change their teaching practices to coincide with these pedagogies, and when they do change, it occurs at differential rates. The aim of this study was to better understand teachers' self-systems by analyzing their experiences in a PD institute program through the lens of professional identity. This multiple case study involved five high school science teachers participating in a summer PD initiative. Data were collected through interviews, written reflections and exploration and commitment cards. Data were analyzed using the Dynamic Systems Model of Role Identity (DSMRI, Author, 2012), which highlights the dynamic interplay of teachers' self-perceptions, beliefs, purposes, and practices. The model of professional identity served to capture teachers' experience of the PD, including tensions that arose as they began to explore portions of their professional identity. This emergent model can provide a conceptual tool for future use as well as guide evaluating and designing PD experiences for teachers.

An Exploration of Science Coordinator Practices following Professional Development

Brooke A. Whitworth, Northern Arizona University
Jennifer Maeng, University Of Virginia
Randy L. Bell, Oregon State University

ABSTRACT:
This study explored science coordinators' practices supporting teachers' science instruction and how they designed and implemented professional development (PD) for teachers. Each of these science coordinators had participated in in PD designed for science coordinators that aligned with a situated learning model. This qualitative case study included 3 science coordinators from three different districts in a mid-Atlantic state and principals and teachers from those districts. Data included observations of science coordinators, surveys,

artifacts, and interviews with science coordinators, principals, and teachers. A constant-comparative approach was utilized to analyze the data for each case and to develop case profiles, then cross-case analysis was used to look for similarities and differences across the cases. Results indicated coordinators supported their teachers through newsletters, emails, resources, websites, walk-throughs, and PD. The PD strategies varied across science coordinators and included in-service days, one-on-one PD, after-school opportunities, and integrating science with other subjects. District characteristics and science coordinator teaching backgrounds influenced their practices. Finally, all 3 coordinators' practices aligned with many of the goals of the PD, suggesting that the PD for science coordinators was effective in facilitating implementation of support strategies for reformed-based science instruction to new settings.

Expertise and Boundary Objects in Teacher-Scientist Partnerships: A Comparative Case Analysis
Jerine Pegg, University Of Alberta
Marie-Claire Shanahan, University Of Calgary
ABSTRACT:
The partnering of scientists and teachers has been used as a model to promote science education reform for more than two decades. One of the arguments for these partnerships is that by engaging as collaborators and co-learners both scientists and teachers will benefit from the other's expertise. In this paper, we examined two multiple-case studies of teacher-scientist programs in which the program goals explicitly acknowledged the expertise that the teachers and scientists brought to the collaboration. We drew on the concepts of boundary objects and the research on interdisciplinary collaborations to provide a framework for the examination of expertise interactions in the teacher-scientist partnerships in this study. Comparison of the two projects highlighted the importance of identifying suitable boundary objects to anchor the partners' collaborative work and incorporate each other's expertise within their particular contexts. In cases where boundary objects were not present or were anchored more heavily in the scientists' or the teachers' social worlds, the expertise of the other tended to be de-emphasized, narrowed, and de-valued in regards to its contribution to the partnership. Furthermore, aspects of perceived status and hierarchy also influenced the ways in which the participants interacted and perceived each others' expertise.

Professional Learning Communities as 'Third Spaces': Bridging the Gap between Science Educational Research and Practice
Cheryl A. McLaughlin, University of Florida
ABSTRACT:
There is a growing divide between the knowledge generated from science education research and that constructed through the practice of teaching. The practice of science teaching hinges on contextual factors that cannot be addressed by the mere application of universal theories or ideas generated from educational research. While science instructions should ideally be informed by scholarly research, science teacher educators will need to find more innovative ways to translate research findings into practical knowledge that teachers are likely to readily adopt. This qualitative study employs a Straussian grounded theory approach to verify claims that collaborative initiatives such as professional learning communities (PLCs) could bridge the gap between contrasting types of knowledge constructed through research and practice. The hybridity theory was used as a lens to interpret the themes generated from the data analysis. Findings suggest that while engaging in hybrid activities in the PLC, the science teachers reconstructed aspects of their practice by negotiating codified knowledge from a reform curriculum and practical knowledge garnered from their experiences in the classroom. The PLC provided a 'third space' in which carefully designed activities provided a scaffold for science teachers as they attempted to translate research into practice.

Strand 9: Reflective Practice
Symposium - Living Authenticity in Science Education Research

2:45pm - 4:15pm, Columbus CD
Presider: Bronwen M. Cowie, University Of Waikato/WMIER
Presenters:
Jennifer D. Adams, Brooklyn College, CUNY
Christina Siry, University ofof Luxembourg
Carolina Castano, Australian Catholic University
Ralph Levinson, Institute of Education London
Michelle D. Brendel, University of Luxembourg
Bronwen M. Cowie, University ofof Waikato/WMIER
ABSTRACT:
This interactive symposium will be an interactive discussion about Guba and Lincoln's (1989) Authenticity Criteria in STEM education research. It will bring together an international panel of science education researchers who research in different contexts (formal, informal, urban, rural, etc.) and different topics, but who all use sociocultural theoretical lens and address issues of equity and social justice. We will discuss our respective research projects and while reflecting on the question of how we are (or are not) enacting the Authenticity Criteria in our practice. We aim for this symposium to be dialogic and plan to engage all participants in several key questions including, "What does it mean to enact science education research through the lens of the Authenticity Criteria?" and "What does it truly mean to do stakeholder focused research?" These and other question are all the more important as we think about equitable practices, meeting the needs of diverse learners and STEM education in a global context. This will be an important symposium for all who are engaged in qualitative research and concerned with improving STEM education and access for all learners.

Strand 10: Curriculum, Evaluation, and Assessment
Assessment Strategies and Issues
2:45pm - 4:15pm, Grand D North
Presider: Gavin W. Fulmer, National Institute of Education

Involving Teachers in Developing Assessments Aligned with NGSS using a 7-Step Process
Chanyah Dahsah, Michigan State University & Srinakharinwirot University
Jane J. Lee, Michigan State University
Angela H. DeBarger, SRI International
Daniel N. Damelin, The Concord Consortium
Joseph S. Krajcik, Michigan State University
ABSTRACT:
Developing assessment tasks that align with the intent of NGSS is an essential task for science educators and teachers. In this study, we purpose a 7 – Step process based on evidence-centered design (ECD) for developing assessment tasks that use DCIs, CCCs and Practices and explore how the 7-Step process helps science teachers develop assessment items align with NGSS. The 7-Step process consists of 1) Select the Performance Expectations (PEs), 2) Unpack the PEs, 3) Develop Learning Performances (LPs), 4) Develop Design Patterns for LPs, 5) Generate Tasks, 6) Develop Rubrics, and 7) Review Tasks. We conducted professional development with 14 science teachers. The results indicated that the 7-Step process has potential to support teachers in unpacking and elaborating relevant disciplinary core ideas, practices, and crosscutting concepts, and in developing appropriate LPs at the instructional level for building tasks and rubrics. It also facilitated teachers in interpreting and understanding the Framework for K – 12 Science Education and NGSS. Some teachers expressed difficulty unpacking PEs, and developing and articulating LPs, since these processes need more time and effort. The teachers stated that working with dedicated peers and knowledgeable facilitators gave support in developing items align with NGSS.

Detecting Sources of Science Performance Differences in K-12 Classroom Assessments by Structural Equation Model

Ting Wang, University of Washington
Ross L Matsueda, University of Washington
Ming-Chih Lan, University of Washington
Min Li, University of Washington

ABSTRACT:
Little research has looked over how various sources contribute to student performance in science. This study purports to explore the relationships among gender, race, state reading scores, pre-test scores and post-test scores of science classroom assessments using structural equation model. 296 fifth-grade students in Colorado State participated in this project. We found that gender, race, reading scores and pre-scores could explain 59% variations of post-scores in a science module test. There was a gender difference for the relation between reading scores and science assessments. Females' science performance could be improved roughly 10% more than males' if females could improve their reading ability. Also, females' science performance relied less on their previous knowledge in science domain compared to males.

The Impact of Treating Missing Values as "Incorrect" in Science Knowledge Assessment

David Buschhüter, University of Potsdam
William Boone, Miami University
Andreas Borowski, University of Potsdam

ABSTRACT:
Do you want to discover what science students have learned? Or do you want to penalize students for poor test taking strategies? This issue is rarely addressed in most science education studies in which a test is administered to a sample of students. Almost always, ignoring the impact of the "completeness" of student responses provides a warped assessment of students. Which in turn can result in interventions (informed by warped data) being mistargeted. In this talk we demonstrate the impact of utilizing a simple coding technique and Rasch measurement techniques to provide an unbiased assessment of student performance. We argue that in quantitative science education studies, the assessment of missing data and addressing this issue when computing student measures should be de rigueur, just as the computation of statistical significance and effect size is understood as requirement of reporting statistical work in science education studies.

Misconception or Lack of Knowledge: Using Confidence to Enhance Measurement Validity in a Multi-tiered Assessment

Dannah L Schaffer, University of Missouri
William Romine, Wright State University
Lloyd H. Barrow, University of Missouri

ABSTRACT:
This study examines the development of a valid Diagnostic Test of the Water Cycle (DTWC) for college students. Most multi-tiered assessments (MTAs) are two-tier, but there are currently a few three-tier MTAs (e.g., DODT, Authors, 2007; SECDT, Pesman & Eryilmaz, 2010), and one four-tier (e.g., Properties and Propagation of Mechanical Waves, Caleon & Subramaniam, 2010). Three-tier and four-tier assessments involve the use of a confidence tier, which allows students to rate their strength of confidence in their selected answers to the first and second tier levels. Through validation of the DTWC, we describe and implement an analysis strategy through the Rasch framework to quickly determine undergraduates' conceptual knowledge of the water cycle, to diagnose their scientific misconceptions, and to see how strongly these misconceptions are held by participants. Reliability and validity of a 3-tiered assessment such as the DTWC depends upon how it is used. We demonstrate the efficacy of the second (reason) and third (confidence) tiers for improving the diversity, utility, and validity of the DTWC.

Assessment in Science Literacy with Cultural Validity: Coping to Diversity and Equality
Carlos M. Garcia, Universidad de Guadalajara
ABSTRACT:
The main challenge of a national institutional evaluation in México, as elsewhere, is to design assessment addressed to different socio cultural contexts. Building a Science Literacy Configuration (SLC) in a group of non-mainstream students, lead us to comprehend the hindrances of their diversity in front of a Science test. Video and ethnographic recordings of Science class were used to design a contextual evaluation with ten items from three modified PISA test questions. We find that the strongest interactions of SL evaluation were linked to: emotional experience of tension and to meaning negotiation. Followed by the relation to natural Science literacy, and the weakest with academic content. Transformation in assessment of content and format is not enough to cope with socio economic limitations, but an alternative is found. Although aligning teaching and evaluation and transformed items improved the average ability of the 20 junior high students to answer, their oral expressions were more meaningful than the written ones. Negotiation of individual oral responses, improves science learning and outcomes assessment, but not those of the group. The link between socio economic conditions and SL was more significant depending of the quality of everyday interactions.

Strand 10: Curriculum, Evaluation, and Assessment
STEM Integration
2:45pm - 4:15pm, Columbus GH
Presider: Maik Walpuski, University of Douisburg-Essen

Innovative Technology in Science Inquiry: Preparing Students for STEM
Elham Beheshti, Northwestern University
Josh Littenberg-Tobia, Boston College
Carolyn Staudt, Concord Consortium
ABSTRACT:
This study investigates a comprehensive approach to inquiry-based science education by engaging students in inquiry-based science projects that use open source computational models and real-time data acquisition with probeware. In this paper, we present 4 years of research findings from our research program with more than 4000 students from upper elementary to high school. In particular, we are interested in the following research questions: (1) did a comprehensive approach to inquiry-based science education increase students' understanding of standards-based content? (2) Did this approach increase students' interest and attitudes towards STEM careers? We investigated students' understanding of standards-based content using pre- and post-tests and the STEM interest and career data was measured using pre- and post-surveys in the beginning and end of the school year. Overall, our study was positively associated with increases with students understanding of standards-based content. Also, students at all grade levels reported statistically significant increases in interest in STEM careers and the largest increases in interest were for careers in engineering fields.

STEM Integration in the Middle Grades: A Study of Teacher Curriculum Development
Emilie A. Siverling, Purdue University
Corey A. Mathis, Purdue University
Tamara J. Moore, Purdue University
Aran W. Glancy, University of Minnesota
S. Selcen Guzey, Purdue University
ABSTRACT:
There is currently a movement in K-12 education to include engineering design learning ideas in science curricula, as can be seen in the Next Generation Science Standards (NGSS). One manner of adding engineering to science classrooms is through STEM integration, a research framework defined as the merging of the

disciplines of science, technology, engineering, and mathematics (STEM). This research project posits two main types of STEM integration: context integration and content integration. This multiple-case study used content analysis to assess curricula developed by fourth through eighth grade teachers of science involved in a teacher professional development focused on STEM integration. The findings demonstrate that the overall STEM integrated units used content integration, but the lessons within were classified as content integration, context integration, a combination of both, or single disciplined. This research advances our understanding about how teachers develop STEM curricula in an interdisciplinary manner with the intent of implementing engineering in K-12 classrooms. By researching how content and context integration are used to address engineering, science, and mathematics standards, this project adds to the theoretical basis for curriculum development in STEM integration environments where engineering is the key to the integration.

Studying the Effects of Interventions across Multiple Content Areas: Solving Measurement Challenges

Molly Stuhlsatz, BSCS
Christopher Wilson, BSCS
Joseph A. Taylor, Abt Associates Inc.
Kathleen J. Roth, Cal Poly Pomona Foundation

ABSTRACT:
In this paper we report on a study that included four content outcomes combined into one measure. We describe our approach to developing measures that can be effectively combined, as well as a method of combining scores across tests using the Rasch measurement model. Two significant measurement challenges emerge from this practice: 1) how to obtain sufficiently similar measures across content areas, and 2) how to make meaning of results in aggregate, especially when statistical power is essential. The development of IRT-type methods, in particular the Rasch Model is providing educational researchers options for solving complex measurement issues. This paper will be of interest to a wide range of researchers who face the challenge of estimating effects when multiple content areas are involved.

Perceptions Related to the Exclusion of Geosciences in the Common U.S. Biology-Physics-Chemistry Progression

Alice (Jill) Black, Missouri State University

ABSTRACT:
For almost 100 years, Earth sciences have been largely omitted from the dominant Biology - Chemistry – Physics progression of science courses in U.S. high schools. Has this omission affected the way Americans, specifically potential geoscience majors and future policy makers and teachers, think about the geosciences? To understand possible perceived reasons for the current progression, an open-ended essay questionnaire was administered to 244 subjects. Responses were coded and used to write items on a new quantitative questionnaire concerning reasons the Earth sciences are not commonly taught in U.S. schools. The questionnaire was administered to five groups, totaling 345 subjects, including introductory geology students, preservice teachers, practicing teachers, and community college students. Results on the qualitative survey showed many negative and unwarranted assumptions about geosciences in comparison to other science disciplines. Results on the quantitative survey were tallied and the ten most commonly chosen response items compared by group and discussed. Possible responses to the current lack of secondary school geosciences are discussed and a call made for invested parties to work together to change the "image problem" of the geosciences and get Earth sciences back into the course progression for college-bound, as well as non-college bound, students.

Strand 11: Cultural, Social, and Gender Issues
Symposium - Linguistically Diverse Learners and STEM Practices
2:45pm - 4:15pm, Grand Suite 5
Presenters:

Enrique Suarez, University of Colorado, Boulder
Kerri Wingert, University of Washington
Shakhnoza Kayumova, University of Georgia
Annie Camey Kuo, University of Washington
Carrie A. Strohl, University of California
Susan G. Harper, University of Georgia
Trish L. Stoddart, Unuversity of California, Santa Cruz
Sara E. Tolbert, University of Arizona
Preetha K. Menon, UC Santa Cruz
Rachel Fisher, University of Arizona

ABSTRACT:
The emphasis on science and engineering practices in NGSS gives rise to discourse-rich learning environments, which raises concerns on accessibility for students who are learning English as a second language. This symposium investigates how - and whether - teachers generate equitable opportunities to learn for students classified as English Language Learners (ELLs). Each presenter leverages qualitative research investigating the ways that English learners participate in science practice-focused education, while drawing implications for what instructional practices and structures support their learning. Since science meaning-making in the context of NGSS reform involves teachers engaging with students, we include posters on teacher attitudes toward linguistically diverse students (posters 3 & 7) and analysis of ELLs' activity in science (posters 1, 2, 4, 5, 6, & 8). This symposium will be structured as a facilitated poster session, including lightning talks (5 minutes each) from each presenter followed by self-regulated interaction at individual posters. We will split these sessions into two groups (four posters each) to allow presenters time to interact at other posters. We will conclude the symposium with a discussion moderated by the organizer highlighting trends across posters to advance theories for prioritizing scientific practices for English Language Learners.

Strand 12: Educational Technology
Educational Technology and Science Education
2:45pm - 4:15pm, Columbus AB
Presider: Noemi Waight, University at Buffalo

Comparing Primary School Students' Understanding and Actions When Experimenting with Physical and Virtual Manipulatives in Science

Zacharias C. Zacharia, University of Cyprus
Marios Michael, University of Cyprus
Georgios Olympiou, University of Cyprus
Vasoula Papasozomenou, Acropolis Lyceum

ABSTRACT:
This study aimed at investigating the effect of experimenting with Physical Manipulatives (PM), Virtual Manipulatives (VM), and a blended combination of PM and VM on primary school students' understanding of concepts in the domain of Electric Circuits and whether any possible differences relate to the processes/actions that students engage in during PM or VM experimentation. A pre-post comparison study design was used for the purposes of this study that involved 55 participants assigned to three conditions. For blending VM and PM a framework from prior research was used. All conditions used the same inquiry-oriented curriculum materials and procedures. A conceptual test was administered to assess students' understanding before and after teaching. Process-related data were derived from video data. Results revealed that the use of the blended combinations enhanced students' conceptual understanding in the domain of Electric Circuits more than the use of PM or VM alone. This difference emerged because only the blended combination was carrying both of PM's and VM's advantageous affordances. Finally, specific VM and PM affordances were found to differentiate PM and VM

students' processes/actions during experimentation, which in turn were found to affect students' conceptual understanding.

Using Technology to Overcome Fundamental Literacy Constraints for Students with Learning Differences to Achieve Scientific Literacy

Clement V. Gomes, Teachers College, Columbia University
Felicia Moore Mensah, Teachers College, Columbia University

ABSTRACT:
The learning disabilities that affect many students can cause them to have difficulty with language-based communications in the form of reading and writing. This study addresses how the use of audio assistive technologies can help students with learning differences/ disabilities ease the burdens of understanding science language and vocabulary. This research is supported with scholarly references. The methodology is based on qualitative research in the form of interviews and observations supported with quantified field data collected and analyzed from pretest and posttest results before and after using the different audio technologies on the iPad. This study on how audio technology can be effective to achieve science education goals for learning disabled students is presented as a case study. The study is done through the lenses of learning disabilities and the importance of technology for advancement of science literacy and education for all students.

Using Evidence for Civic Action from News Media with Multiple Perspectives

Eva Erdosne Toth, West Virginia University

ABSTRACT:
The 2015 NARST conference focuses on the nature of changes in science education to accommodate the needs of the public based on current policies. Along these lines this presentation builds on recent perspectives on combining competencies we currently teach under compartmentalized disciplines: science education, literacy and social studies. The presentation outlines three fundamental problems with the current approach and suggests possible future actions for science educators. In specific, the research questions focused on elementary teacher candidates' use of evidence from media sources to support a civic decision in the context of applying novel technological tools for recovery after a natural disaster. The analysis indicated that teacher candidates considered evidence from readings, historical trends, personal observations and combined these with their own personal values and worldviews as a source of evidence for action. The results provide evidence for the further development of instructional methods to ensure the education of scientifically literate citizens who are ready for civic actions based on a combination of facts, values and world-views.

Comparing Student Discourse and Actions when Using Simulations with and without Representations of Abstract Objects

Georgios Olympiou, University of Cyprus
Zacharias C. Zacharia, University of Cyprus

ABSTRACT:
This study aimed at identifying how the experimental procedures/actions which students follow, as well as the discourse that takes place during experimentation, differ when the students experiment with simulations that carry or not representations of abstract/conceptual objects in the domain of Light and Color. The participants of the study were 69 undergraduate students of a university in Cyprus. For the purposes of this paper two groups of students were selected from each condition (14 students in total) and were compared in terms of their procedures/actions and discourse for two different experiments of the curriculum followed. The data collection involved two different data sources, namely, videos and screen-captured videos. The data analysis involved the use of a coding scheme from prior research. The results showed that the addition of representations of abstract/conceptual objects in a simulation does not influence students' experimental procedures/actions. However, the presence of representations of abstract/conceptual objects was found to affect the student

discourse. Specifically, students using representations of abstract objects were found to raise almost twice as many questions concerning the scientific content and provide twice as many scientifically accurate answers than the students who did not use such representations.

Strand 14: Environmental Education
Environmental Discourse
2:45pm - 4:15pm, Columbus EF
Presider: Dorene R. Medlin, Albany State University

A Needs Assessment Study for the Development of an Environmentally-focused Professional Development Program
Erica Blatt, College of Staten Island, CUNY
Eugenia Naro-Maciel, College of Staten Island, CUNY
Edita O'Brien, College of Staten Island, CUNY
ABSTRACT:
This study is a needs assessment for the development of an environmentally-focused professional development program for secondary science teachers at two urban public high schools in the Northeastern United States. A qualitative methodology based on interview methods was used to investigate what environmental topics teachers are currently teaching, which environmental topics the teachers would like to incorporate further, what teaching strategies the teachers would like more support in utilizing, and what form of professional development would be most beneficial to them. Participants included 17 Earth Science and Biology teachers with 2-17 years of teaching experience. Results highlight areas of the curriculum in which environmental topics are being taught, topics teachers would like to include, and obstacles to incorporating environmental issues into their teaching. Teachers also discuss teaching strategies, such as hands-on activities and Common Core writing tasks, with which they would like assistance, in addition to their preferred form of professional development. Study findings have been used to suggest possible solutions for overcoming the obstacles described by teachers, which will be important in developing an effective environmentally-focused professional development program.

"I Walk with More Confidence": Understanding Ecological Mindfulness through Pre-service Elementary Teachers' Conceptions and Practices
Gretchen D. Perkins, University of Georgia
Heather Rudolph, University of Georgia
Young Ae Kim, University of Georgia
Deborah Tippins, University of Georgia
ABSTRACT:
Eco-mindfulness is a set of skills that can be developed and informally practiced by a person with their experiences in, and with, their environment. It can be characterized by the sustainable practices a person develops and then teaches to his/her students or the mindful actions that he/she takes in his/her daily life in his/her environment. Twenty pre-service elementary education teachers in a science teacher preparation course were given a pre- and post-survey to assess their eco-mindfulness over the course of the semester. From those 20, five students were interviewed about their conceptions of eco-mindfulness and their photoessay response to Richard Louv’s 2005 book, “The Last Child in the Woods: Saving our Children from Nature Deficit Disorder.” For pre-service elementary teachers, a main component of eco-mindfulness was being aware of nature’s place in their lives. A shift toward environmental stewardship was also found.

Science Students' Conscientious Technology Designs to Address Socioscientific Issues
John Lawrence Bencze, University of Toronto
Mirjan Krstovic, Peel District School Board

ABSTRACT:
Many scholars and jurisdictions have urged educators to interrelate and/or integrate education in fields of science and engineering — most recently as 'STEM' (science, technology, engineering & mathematics) education. A promising movement that could assist in this regard engages students in multi-disciplinary decision-making about socioscientific issues, such as debates about (de-)regulation of fossil fuel industries linked to climate change. Some scholars also suggest, however, that, because of significant problems associated with capitalist influences on fields of science and technology, much more politicized and action-oriented education is necessary. Accordingly, we studied promotion of secondary students' research-informed technology designs of possible for-profit commodities that considered the wellbeing of individuals, societies and environments. Qualitative results suggested that students not only were able and willing to design socially and environmentally conscious technologies, but they did so in ways considering a range of interconnected and often-hidden living and non-living, and associated semiotic, actants. In other words, when conceiving of commodities, students thought of them as networked — as embodying such actants as miners, advertizers, corporations, bankers, government, manufacturing laborers, etc. This outcome may interest educators and policy-makers open to critical and liberatory technoscience/STEM education.

Plenary Session #1

STEM Vital Signs
4:30pm – 5:50pm, Grand Ballroom CD South, EF
Presider: Valarie Akerson, Indiana University
Keynote Presenter: Linda P. Rosen, CEO, Change the Equation

ABSTRACT:
We stand at a critical moment in efforts to develop a globally competitive STEM workforce. Since the roots of that workforce lie in K-12 education, Change the Equation, a coalition of major companies, work collectively through their philanthropy and advocacy to ensure that all high school graduates are STEM literate. Decisions on which programs to fund and which policies to support are grounded in research to help ensure the greatest outcomes. Now in its fourth year of operation, CTEq is pleased to describe what's working and what needs attention.

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

Contemporary Methods for Science Education Research RIG Sponsored Session
Prevailing Questions and Methods in Science Education: An Analysis of the NARST Conference Program
8:30am - 10:00am, Grand B
Presenters:
Binaben Vanmali, Arizona State University
Susan Kowalski, BSCS
Stanley Lo, University of California, San Diego
Susan O'Brien, Oregon State University
Molly Stuhlsatz, BSCS
Joseph Taylor, BSCS
Christopher Wilson, BSCS
ABSTRACT:
This interactive session will feature a report by the NARST Methods RIG leadership team on the recent prevailing research questions and methods of the NARST community. The source of this information is an analysis of the 2014 NARST conference program. This report is intended to stimulate small group discussions that focus on dialogues such as the following: • What about the results were expected, unexpected? • To what extent are the prevailing questions consistent with the NGSS Research and Development Agenda (NRC, 2012)? • Where do the prevailing questions fall in the Cycle of Innovation described in the joint publication: Common Guidelines for Education Research and Development (NSF/IES, 2013)? • What are the implications of these results? • How can the NARST Methods RIG support pursuit of the most important and timely questions and the most appropriate methods?

International Committee Sponsored Session
Understanding and Negotiating Non-participation in Science Learning: Is Science 'For Me' or Not?
8:30am - 10:00am, Gold Coast
Presiders:
Hsiao-Lin Tuan, NARST, Taiwan
Manuela Welzel-Breuer, ESERA, Germany
Discussant: Jennifer DeWitt, King’s College London, United Kingdom
Presenters:
Billy Wong, King's College London
Fredrik Jensen, University of Oslo
Ellen Karoline Henriksen, University of Oslo, Norway
Bjorn Friis Johannsen, University of Copenhagen, Denmark
Lars Ulriksen University of Copenhagen, Denmark
Lene Moller Madsen, University of Copenhagen, Denmark
Henriette Tolstrup Holmegaard, University of Copenhagen, Denmark
Emily Dawson, University College London, United Kingdom
ABSTRACT:
That some people see learning science as ?important, but not for me? is acknowledged by many in the science education community as a significant problem for engagement with and participation in science learning. In response, this symposium explores equity and diversity in science learning with attention to the ways in which exclusion, non-participation, attitudes, educational structures and individual experiences are intertwined. These

four papers explore the extent to which individuals, particularly those from marginalised groups, see learning science as ?for them? or not and how their relationships with science education can be renegotiated through outreach schemes or their own actions. The first paper describes research with high achieving minority ethnic secondary school students, who may be regarded as ?clever? but nevertheless view science careers as ?not for me?. The next paper focuses on gender and efforts to encourage girls to pursue STEM subjects in higher education. Following this, the participation of students in STEM higher education programmes will be discussed in relation to how some individuals renegotiate the curriculum on offer in a physics course in order to make space for their own aims, interests and learning needs. Finally, the fourth paper broadens the focus to consider the non-participation of individuals from disenfranchised, minority ethnic groups in life-long science learning experiences. Thus the attitudes and experiences of groups with four different perspectives are presented, in order to highlight the multiple and often overlapping ways in which science learning can prove difficult and off-putting for some people. The symposium will conclude by discussing the multiple ways in which exclusion and non-participation are entangled, which makes important questions of equity and diversity in science learning complex both to research and to address in practice.

Strand 1: Science Learning, Understanding and Conceptual Change
Trends in Instructional Use of Visualizations and Other Representations
8:30am - 10:00am, Columbus GH
Presider: Susan Hawkins, Indiana UniversityUniversity

Student Reasoning During Conceptual Physics Problem Solving with Visual Cues or Feedback
Elise Agra, Kansas State University
Mitchell Burkett, Kansas State University
John Hutson, Kansas State University
Lester C. Loschky, Kansas State University
N. Sanjay Rebello, Kansas State University
ABSTRACT:
Research has demonstrated that visual cues can help direct students' attention to relevant areas of a diagram and facilitate problem solving. In this study, we investigate the effect of visual cues and correctness feedback in conceptual physics problems containing a diagram with respect to the comprehension of physics concepts. Students enrolled in an introductory mechanics course were individually interviewed. Using a think-aloud protocol, students worked through four sets of problems containing a diagram. Each problem set contained an initial problem, six isomorphic training problems, a near transfer problem, and a far transfer problem. The students provided verbal responses to the problems. Students in the cued condition saw visual cues on the training problems, and students in the feedback condition were told whether their responses were correct or incorrect. We discuss the influence of both cueing and feedback on students' reasoning in the training and transfer problems.

Supporting Representation-rich Problem-solving in High School Physics
Lyrica L. Lucas, University of Nebraska-Lincoln
Mark Shearer, Lincoln Public Schools
Elizabeth B. Lewis, University of Nebraska-Lincoln
ABSTRACT:
The literature on physics education research promotes the use of multiple representations (such as pictures, diagrams, written explanations, and mathematical expressions) to enhance the problem-solving ability of students through instruction. This study explored the use of a scaffolding strategy that involved the use of multiple representation tasks in problem-solving in a modeling physics class in high school. Another class with

similar background was selected as a comparison group. In 12 in-depth problem-solving interviews of students drawn from the two classes, we investigated how the students responded to the tasks and how it affected their problem-solving performance, use of representations, and the quality of their representations compared to students who were not guided to generate representations in solving similar problems. Aggregate data on student problem-solving performance and use of representations was collected from 14 homework problems and crosschecked with findings from cognitive interviews. More students from the scaffolding group constructed visual representations in their problem-solving solutions, while their use of other representations and problem-solving performance did not differ with that of the comparison group. Also, the data from the interviews revealed that students do not believe in the necessity of writing down physics concepts despite being encouraged to do so.

Transforming Linguistically Diverse Students' Misconceptions about Matter and Energy Flow Using Visualizations

Emily Toutkoushian, University of North Carolina-Chapel Hill
Melody Kung, University of North Carolina-Chapel Hill
Kihyun (Kelly) Ryoo, University of North Carolina, Chapel Hill

ABSTRACT:
Visualizations are a potentially useful tool for addressing misconceptions about photosynthesis and cellular respiration. Compared to static visualizations, dynamic visualizations are able to fluidly show simultaneous processes; however they may make it difficult for students to extract and understand important information. Additionally, there has been little research into the effects of visualizations on linguistically diverse students' understanding of science concepts. This study compares the impact of dynamic and static visualizations on decreasing the misconceptions about energy and matter flow in photosynthesis and cellular respiration for 149 seventh graders. Students completed a web-based inquiry unit on photosynthesis and cellular respiration in either the static or dynamic condition. To gauge whether the dynamic or static visualizations were more effective in decreasing misconceptions, pre- and posttest responses from the two conditions were coded and compared using chi-square and McNemar tests. To investigate the impact of the type of visualization on English Language Learners' (ELLs) and English Proficient Students' (EPSs) misconceptions, pre- and posttest responses for those groups were also compared. Dynamic visualizations were found to be more effective than static visualizations in decreasing misconceptions for ELLs and EPSs. This study has implications for curriculum design and teaching of diverse learners.

Investigating High School Students' Visualization Competence of Matter

Hsin-Yi Chang, National Kaohsiung Normal University
Shi-Fang Tzeng, National Kaohsiung Normal University

ABSTRACT:
Students' ability to visualize their ideas on scientific phenomena and use the visualization to understand science concepts is important in light of science education goals and 21st century knowledge and skills. Such ability requires students to construct multiple representations in their visualizations. We synthesize research on visualization and representation to propose a framework of visualization competence including four components: constructing, interpreting, transforming and critiquing visualizations. According to the framework, we developed and validated an assessment that measures students' visualization competence of matter. We administered the assessment to 762 7th to 12th grade students at one public high school in Taiwan. The students had started to learn concepts of matter at the particulate level since the 7th-grade. However traditional assessments rarely measured students' visualization competence. It is unclear how well the students performed on visualization of matter across grade levels. Overall the results indicated that the students' visualization competence got better as they advanced to higher grades. However the percentages of students' alternative

conceptions or non-particulate visualizations of matter did not decrease or increase by grade. Implications for science learning and teacher were discussed.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set - Engaging Students in Scientific Practices: The Role of Teachers in Providing Opportunities for Student Learning
8:30am - 10:00am, Grand Suite 3
Discussant: Leema Berland, University of Wisconsin-Madison
ABSTRACT:
Recent reform efforts aimed towards a more comprehensive view of science teaching and learning reflect an increasing emphasis on the integration of scientific practices in the classroom. Teachers will play a critical role in how this is done, but little research has specifically focused on addressing the compelling need to understand how teachers can support students' engagement in meaningful science learning through participation in science practices. This paper set discusses research towards this end from four different projects. Paper 1 explores the success and challenges faced by a teacher and her students in a middle school sheltered English immersion classroom as they engage in the language intensive science practice of argumentation. Paper 2 suggests argumentative discourse permeates all science practices, and shows how a few teacher talk moves shifted classroom discourse to better reflect desired reform efforts. Paper 3 provides insight into how teachers think about modeling over time, and how these ideas affect their teaching practices. Paper 4 explores the types of adaptations teachers make to curriculum materials intended to integrate science content and science practices, and whether these adaptations mirror the goals of the Next Generation Science Standards.

Analyzing Teacher Adaptations of Two Investigation-based Science Units: Teaching with the Goals of the NGSS in Mind
Sylvie M. Kademian, University of Michigan
Anna Maria Arias, University of Michigan
Elizabeth A. Davis, University of Michigan
Annemarie S. Palincsar, University of Michigan

Exploring Elementary Teachers' Knowledge and Practices for Model-based Science Instruction about the Water Cycle
Tina Vo, University of Nebraska-Lincoln
Cory T. Forbes, University of Nebraska-Lincoln
Laura Zangori, University of Nebraska-Lincoln
Christina V. Schwarz, Michigan State University

Encouraging Argument as the Connective Discourse of Scientific Practices
William A. Sandoval, University of California, Los Angeles
Sihan Xiao, University of California, Los Angeles
Elizabeth Redman, University of Califorina - Los Angeles
Noel Enyedy, University of Califorina - Los Angeles

Successes and Challenges Experienced by a Teacher and Her Students Engaging in Scientific Argumentation in a Sheltered English Immersion Classroom
Maria Gonzalez-Howard, Boston College
Katherine L. McNeill, Boston College

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Related Paper Set - Science Teachers' Professional Knowledge: Structure, Development, and Relevance for Students' Learning Progress
8:30am – 10:00am, Columbus CD
Presider: Jörg Großschedl, Leibniz Institute for Science and Mathematics Education
Discussant: Norman Lederman, Illinois Institute of Technology
ABSTRACT:
A central challenge for teachers is to support students in their development of subject matter knowledge. This challenge is influenced by various factors, such as students' prior knowledge, intelligence, or motivation. Also, it is influenced by the professional knowledge of the individual teacher, which usually is subdivided into the domain of content knowledge (CK), pedagogical content knowledge (PCK), and pedagogical knowledge (PK). Recently, particular interest has been directed toward CK and PCK, its components, its acquisition, and its influence on the learning progress of students. As the available studies mainly concentrate on mathematics education, the Related Paper Set addresses these issues in the field of science by assembling five studies, which pursue a variety of innovative methodological approaches. Four studies concern the nature of pre- and in-service science teachers' professional knowledge by particularly focusing on the components of CK and PCK as well as on the relationship between both domains of knowledge. Furthermore, one paper focuses on the development of the knowledge domains by investigating the relationship between CK, PCK, PK, and a set of learning opportunities. The last paper of the Related Paper Set relates biology teachers' content related knowledge to students' conceptual knowledge acquisition.

The Professional Knowledge of Pre-Service Physics Teachers
Jochen Kröger, Leibniz Institute
Stefan Petersen, Leibniz Institute
Knut Neumann, Leibniz Institute

Measuring Topic Specific PCK of Electrochemistry in South African High School Chemistry Teachers across 4 Contexts: Similarities and Differences
Marissa S. Rollnick, Wits University
Elizabeth Mavhunga, University of Witwaterrand
Norman G. Lederman, Illinois Institute of Technology

Which Influence does Biology Teachers' Content-related Knowledge has on Students' Conceptual Knowledge Acquisition in Biology Education?
Daniela Mahler, Leibniz Institute
Jörg Großschedl, Leibniz Institute
Ute Harms, Leibniz Institute for Science and Mathematics Education (IPN)

Mathematics and Biology Teachers' Tacit Views of the Knowledge Required for Teaching: Varying Relationships between CK and PCK
Ronit Rozenszajn, Weizmann Institute
Anat Yarden, Weizmann Institute of Science

The Good, the Bad and the Ugly: Connections between Pre-service Science Teachers' Content Knowledge and Pedagogical Content Knowledge
Vanessa Kind, Durham University

Strand 6: Science Learning in Informal Contexts
Symposium - Informal Science Education: Pedagogy and Epistemology
8:30am - 10:00am, Randolph
Discussant: Phyllis Katz, University of Maryland
Presenters:
Patricia Patrick, Texas Tech Unviersity
Preeti Gupta, American Museum of Natural History
Jennifer Correa, New York Hall Of Science
Ayelet Baram-Tsabari, Ayelet Baram-Tsabari, Technion - Israel Institute of Technology
Bruce V. Lewenstein, Cornell University
Leonie J. Rennie, Curtin University
Christine Howitt, Curtin University of Technology
Elaine Blake
Phyllis Katz, University of Maryland
Judith S. Lederman, Illinois Institute of TechnologyTechnology
ABSTRACT:
In this symposium, the presenters share how each has given consideration to the importance of identifying pedagogy and epistemology as they relate to informal science education. Each author share the context in which their approach has been used, and the research methods employed in conducting this research. During this session, the researchers will briefly describe the definition of informal science education and provide an overview of the types of research questions explored using this pedagogy and epistemology as a lens to prepare informal science educator. As we discuss our own research utilizing various methodological approaches, this symposium is intended to expand audience participants' ideas regarding possible application of pedagogy and epistomology. The latter portion of the session will involve a discussion period where audience members will be encouraged to ask questions of the presenters and engage in a conversation regarding commonalities and differences in the work presented, as well as possible future directions for ISE educator preparation research.

Strand 7: Pre-service Science Teacher Education
Related Paper Set - Preparing Teachers to Teach Socioscientific Issues: Global Concerns and Challenges
8:30am - 10:00am, Grand D North
ABSTRACT:
For new teachers and those who have not tried integrating complex social issues into their instruction, SSI-based teaching may seem too great a hurdle to overcome. How then do we begin bridging the theory-practice divide? The aim of this paper related set is to bring together researchers from three different continents (USA, Europe, Australia) that engage in research related to bridging the gap between theory and practice in teaching SSI. The four papers cover issues of difficulties that pre-service teachers have as learners of SSI, challenges in designing SSI related lessons, concerns in implementing SSI as part of the teaching, and struggles in assessing learning in SSI contexts. Furthermore, our group of papers covers the range of preparing both elementary and secondary science teachers to teach SSI, and the different challenges that they face. Our main aim is through the discussions to gain a better understanding of how research in other countries and contexts can potentially help us to bridge the gap between theory and practice when it comes to teaching SSI, and explore common themes between preparing teachers to teach SSI in the three continents.

Can Pre-service Elementary School Teachers Teach Socioscientific Issues?
Maria Evagorou, University of Nicosia
Digna Couso, Crecim-Universitat Autonoma de Barcelona

Anna Garrido, Crecim-Universitat Autonoma de Barcelona

A Teacher-Researcher Collaboration for SSI-based Teaching and Learning
Troy Sadler, University of Missouri
Patricia J. Friedrichsen, University of Missouri-Columbia
Kerri Graham, Rock Bridge High School

Possibilities and Limitations from a Short Methods Course in Socioscientific Teaching
Jan Alexis Nielsen, University of Copenhagen
Robert H. Evans, University of Copenhagen

Preparing Australian Science Teachers to Teach Socioscientific Issues
Vaille Dawson, The University of Western Australia

Strand 8: In-service Science Teacher Education
Inservice Science Teacher Education Reform
8:30am - 10:00am, Roosevelt
Presider: David F. Jackson, The University of Georgia

Supporting Large Scale Change in Science Education: What We Have Learned So Far
Arthur Eisenkraft, University of Massachusetts Boston
Ayana M. McCoy, University of Massachusetts Boston
Abigail Jurist Levy, Education Development Center, Inc.
Frances Lawrenz, University of Minnesota
Janna Kook, Education Development Center, Inc.
Barry J. Fishman, University of Michigan
Christian Fischer, University of Michigan
Chris Dede, Harvard University
Kim Frumin, Harvard University
ABSTRACT:
The paper will describe a longitudinal mixed-method study that examines the professional development choices of teachers when faced with a large-scale curriculum change and the relationship between teachers' PD choices and student outcomes. The study takes advantage of a unique opportunity to explore how 20,000 high school AP science teachers response to a dramatic change in their curriculum through their choice of professional development and how these choices relate to gains in student performance using the AP exam scores a measure. 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:10.0pt; font-family:Cambria;} Preliminary data analysis indicates that teachers' PD choices vary widely. Teachers also indicated challenge areas in adapting to the redesigned curriculum. These findings suggest that different PD options may be required to fit teachers' needs, especially as they relate to student learning and performance. This study contributes to the knowledge of large-scale professional development efforts, particularly as they relate to the Next Generation Science Standards. It also offers lesson for future professional development efforts of the AP Science redesign and all AP courses.

After the Love (and Money) is Gone: Factors Sustaining Elementary Science Reform

David E. Long, George Mason University
Danielle M. Kittrell, George Mason University
Andrew J. Keck, George Mason University
Susan Poland, George Mason University
Cheryl O'Connor, George Mason University

ABSTRACT:
In an intensive science education reform professional development for elementary teachers, problem based learning, inquiry, hands-on science, and the nature of science are learned and practiced. Teachers receiving this program return to schools and receive ongoing supports for this pedagogy. This study returns after two years to assess factors that sustain or dissipate teacher use of these pedagogies.

The Role of the School Principal in K-12 Science Education Reform

Rachel Ruggirello, Washington University in St. Louis
Sonya N. Martin, Seoul National University

ABSTRACT:
Well-informed principals are essential to fostering the changes that will be needed to support visions of effective science teaching and learning according to the NGSS. In this study, we examine the challenges administrators face in supporting science education reforms and we describe how professional development programs can better prepare principals to affect sustainable science reform in their individual school settings. This study utilizes a two-phase mixed methods design by employing both quantitative analysis of data from a validated survey instrument and a qualitative analysis of administrators' and teachers' experiences within the context of their involvement within the MSP. Analyses suggest that administrators lack leadership content knowledge necessary to support reforms in science teaching and learning. In addition, administrators face multiple challenges including feelings of isolation and a lack of self-efficacy to support science teachers. This study reports that a professional development model where principals work collaboratively with teachers can influence administrator knowledge and actions related to reforms in science teaching and encourage administrators and teachers to work collaboratively improve student understanding of and achievement in science.

Teacher Community Structure and Rural Science Education Reform

Bill Zoellick, Schoodic Institute

ABSTRACT:
Sustaining science education improvement in rural settings typically requires bringing together many school districts. But bringing together teachers from different districts creates a tension between a teacher's focus on working within his or her own school district and the need to build and strengthen connections to the larger, cross-district community. Externally funded improvement initiatives that do not succeed in creating a large number of rich cross-district connections among teachers may have difficulty sustaining the initiative beyond the end of funding. Using social network analysis, this paper tracks the growth of cross-district connections between teachers over four-years of investment in a rural science education improvement program. It documents initial difficulty in creating cross-district connections followed by subsequent growth of such connections. It describes and explores the impact of changes in program structure that may be contributing to increased teacher engagement in the activities and concerns of the project's overall, cross-district community.

Strand 8: In-service Science Teacher Education

Research on Elementary Science Teacher Education

8:30am - 10:00am, Columbus AB

Presider: Christopher A. Bogiages, Knowles Science Teaching Foundation

Teachers Talking about Talk: What Elementary Science Teachers Identify as the Value and Barriers to Science Discourse Pedagogy

Kirstin C. Busch, Stanford University
Eric Berson, Stanford University
Anita Tseng, Stanford University
Hilda Borko, Stanford University
Jonathan Francis Osborne, Stanford University

ABSTRACT:
The Framework for K-12 Science Education highlights the pivotal role of discourse and argument to both student learning as well as professional science (National Research Council, 2012). Despite the frequent talk that occurs throughout the practice of science, student discourse is often lacking in many U.S. science classrooms (Osborne, 2010). If we seek to advance scientific discourse as an important instructional practice, it is important to understand why discourse is not occurring in science classrooms. This study investigates teachers' beliefs about the features, value of and barriers to engaging students in scientific discourse practices. An analysis of interviews with 59 elementary school teachers from a large urban school district found that teachers conceptualized discourse in common ways and attributed value to the instructional practice. However, they identified many barriers that make it difficult for them to productively engage their students in scientific discourse. Implications for the design of professional development to address these barriers are discussed.

The Effect of Professional Development on Elementary Teachers' Understanding and Implementation of Reforms-based Science Instruction

Randy L. Bell, Oregon State University
Jennifer Maeng, University Of Virginia
Timothy Konold, University of Virginia
Brooke A. Whitworth, Northern Arizona University

ABSTRACT:
This cluster randomized controlled trial (RCT) characterized changes in teachers' understanding and classroom implementation of reforms-based science instruction and their students' achievement on end-of-course assessments following participation in a state-wide professional development. The PD was aligned with the characteristics of effective PD and situated learning theory. Across two cohorts, treatment teachers (n=147) attended a 4-week summer institute with sustained follow-up and coaching throughout the academic year, while control teachers (n=117) received no PD/support. Data collection included pre-/post-/year-end Perceptions surveys, post- and year-end interviews, Pedagogical Content Knowledge surveys, classroom observations, and end-of-course student assessment data. Data were analyzed using systematic data analysis and inferential statistics. Results indicated treatment teachers exhibited statistically significant changes in their understandings of nature of science, inquiry, and problem-based learning. Classroom observations indicated the PD facilitated teachers' implementation of these reform-based practices. The situated nature and embedded components of effective PD appeared to contribute to the overall effectiveness of the PD experience. Finally, treatment teachers' students' science achievement scores were greater than those of control group teachers' students. The results of this study have the potential to inform PD supporting elementary science teachers' implementation of reforms-based science practices.

Science Educational Computer Simulations and Elementary Science Teachers

Amanda L. Gonczi, University of Virginia
Jennifer Maeng, University of Virginia
Randy L. Bell, Oregon State University

ABSTRACT:

The purpose of this study was to characterize and compare elementary science teachers' instructional science education computer simulation (SECS) use prior to and after computer simulation professional development. Classroom observation reports, video recorded science lessons, and perceptions surveys were analyzed to identify any possible changes in participants' computer simulation use following computer simulation professional development. In particular, the extent of participants' SECS use and computer simulation implementation to support inquiry or more teacher-centered instruction was characterized. Analysis of data across two participant cohorts indicated the professional development resulted in participants increased computer simulation efficacy and instructional implementation. Participants reported using science education computer simulations most often for science content and inquiry-based teaching following the PD. The data indicate SECS may help bridge gaps in elementary teachers conceptual knowledge and facilitate inquiry-based teaching. Participants described challenges to successful SECS implementation including insufficient computer access and limited pedagogical knowledge. Implications for pre- and in-service elementary teacher education are discussed in light of these findings.

Elementary Teachers' Mindsets: Does Situated Professional Development Promote Growth Mindedness?
Jennifer Maeng, University of Virginia
Amanda L. Gonczi, University of Virginia
ABSTRACT:
The purpose of this sequential explanatory mixed-methods investigation is to (1) examine the extent a professional development (PD) experience for elementary science teachers changes teachers' mindsets and (2) explore contextual factors that may cultivate teachers' growth- or fixed-mindednesss. Participants were 46 elementary science teachers recruited from a cohort currently participating in a state-wide PD program for which alignment with key features of effective PD was previously established. Data included validated pre- and post-PD Mindset Surveys, observations of the PD, and semi-structured follow-up interviews. Survey responses were analyzed via t-tests to identify teachers' mindsets prior to and following the PD. Interview responses and PD observations were analyzed using analytic induction to explore the PD and school culture elements that influenced teachers' mindsets. Results have the potential to help PD developers better understand how to design and implement PD that is effective in facilitating long-term teacher change and may broaden the lenses used to design and evaluate PD by applying a psychological perspective already used to examine variation in K-12 student achievement. Future research will examine what relationship, if any, exists between mindset, implicit goals, and teachers' classroom practice prior to and following reforms-based PD.

Strand 9: Reflective Practice
Reflective Outcomes of Science Classroom Practice Teaching
8:30am - 10:00am, Columbus EF
Presider: Wesley Pitts, Lehman College, CUNY

Teachers' Reflective Practice as a Tool for Following the Development of their Sense of Ownership during a CPD Workshop
Avi Hofstein, Weizmann Institute of Science
Dvora Katchevitch, Weizmann Institute of Science
Malka Yayon, Weizmann Institute of Science
Rachel Mamlok-Naaman, weizmannInstitute of Science
ABSTRACT:
A year long, continuous professional development workshop was conducted in Israel. It was conducted as part of an inquiry-based socio-scientific EU project: PROFILES (Professional Reflection-Oriented Focus on Inquiry-based Learning and Education through Science). The key goal of this project is promote contemporary

science education in order to enhance students' scientific literacy. The objectives of the CPD workshop were mainly to support teachers in: (1) gaining knowledge of different instructional approaches, (2) , teaching the inquiry skills, (3) decision making, and (4) reflection abilities. The CPD model that was used in this study was "The teacher as [a] curriculum developer" in which the teachers that participated in the CPD were intensively involved in the development and implementation of learning modules, while reflecting on the process which they underwent. It is suggested, that providing teachers with an opportunity to reflect on their experiences during a CPD workshop and during the related science classroom implementation may serve as a tool for following the development of teachers' ownership regarding a new program. It was found (based on several methods of reflection both orally and written) that the PROFILES CPD workshop, served as a platform for the development of teachers sense of ownership.

Balancing Identities: Am I a Science Teacher Educator or an Environmental Educator?
Jenna Gatzke, Indiana University - Bloomington
Gayle A. Buck, Indiana University
Valarie L. Akerson, Indiana University
ABSTRACT:
The purpose of this study was to investigate the identity conflicts I was experiencing as an environmental educator entering a doctoral program in science teacher education. My inquiry employed self-study methodology and utilized a variety of data sources, including sixteen weeks' worth of personal journal entries, audio-recordings of four critical friend meetings, and three instructor evaluations completed by my students. Findings from the study show a progression of thoughts, emotions, and questions from initially making constant comparisons between environmental, science, formal, and informal education to three critical instances which led to finding grounding in my own identity as an educator. Overarching connections were found within pedagogical practices. Implications regarding the need for life-long teacher reflection as well as suggestions for ways to build bridges across differing educational fields are discussed.

The Spectrum of Teacher Action Research Projects in Science Classrooms
Marissa Bellino, The Graduate Center, CUNY
Jennifer Adams, Booklyn College- CUNY
ABSTRACT:
The pressure of today's standards, assessments, and accountability measures leaves little room for teachers to conduct a self-study of their professional world. Current education research privileges research that focuses on quantitative and data driven inquiry that supports today's neoliberal education reform agenda. These education reforms leave little time and space for creative action research endeavors by teachers to reflect on their teaching practice and address the multiple inequalities that are embedded in these reforms. This study looks at the variation in action research projects conducted by secondary science educators in a teacher education program. Action projects ranged in participation with some projects embracing participatory action research (PAR) principles of increased participation of stakeholders aimed at transforming unjust school structures to projects that were teacher focused and uphold the education reforms of high stakes testing, Common Core Learning Standards, and teacher evaluation systems. Reflections on the action research process revealed the power of research, the assumptions science teachers hold about research, and the challenges that conducting action research presents in the classroom.

Reflecting on Teaching a Science Course for Pre-Service Teachers
Victoria Deneroff, Georgia College & State University
Rosalie Richards, Stetson University
ABSTRACT:

Students are ill-prepared to meet the needs of the workforce, to participate as informed citizens in a democratic society, or to understand the excitement and intellectual satisfaction of the practice of science, the goal of the Next Generation Science Standards (2012). Our own students, undergraduate science majors and pre-service teachers alike, show little understanding of the nature of science or of its unifying, overarching principles. We argue science education is embodied and socially situated, that is, that it occurs in the persons of the teacher and the students through the social practice of science teaching (Author, 2013; Bryan and Atwater, 2002). Changing the "outcomes" of science learning requires understanding ourselves as teachers, and our students' understanding of what it means to learn science. We tell the story of coming to understand post-secondary science teaching over the course of six years of co-teaching an upper level physical science course for pre-service middle grades teachers.

Strand 10: Curriculum, Evaluation, and Assessment
Symposium - A European Perspective on Inquiry Learning and Assessment in Science
8:30am - 10:00am, Comiskey
Presider: Richard A. Duschl, Penn State University
Presenters:
Gunnar Friege, Leibniz Universitaet Hannover
Eilish McLoughlin, Dublin City University
Peter Labudde, Paedagogische Hochschule FHNW
Christine Harrison, King's College London
Regula Grob, Paedagogische Hochschule FHNW

ABSTRACT:
This symposium provides an overview of the development and implementation of inquiry based science education (IBSE) across Europe during the last decade. Many projects have risen to the challenge set by the Rocard report (2007) to implement and develop IBSE through collaborative endeavor across a range of countries. The approach and emphases of these projects has varied widely but all seek to better engage learners with scientific ideas to prepare them to be citizens of the 21st century. This symposium provides an insight into one such project – ESTABLISH – which developed materials and models for pre- and in-service teachers to strengthen their inquiry approach to teaching in science. It provides a flavor of the type of work that teachers are willing to incorporate to change their classroom pedagogy. One area that has not received much development within the EU inquiry projects until recently has been how to assess inquiry-based learning. Two projects, funded by the EU 7th Framework Program, SAILS and ASSIST-ME are currently tackling this aspect and this symposium reports on findings from both projects.

Strand 10: Curriculum, Evaluation, and Assessment
Symposium - Curriculum Materials for NGSS: What the Science Education Research Community Can Do
8:30am - 10:00am, Wrigley
Discussant: Brian Reiser, Northwestern University
Presenters:
Jo Ellen Roseman, American Association for the Advancement of Science
Joseph S. Krajcik, Michigan State University
David L. Fortus, Weizmann Institute of Science
Brian J. Reiser, Northwestern University
ABSTRACT:
Realizing the vision of Next Generation Science Standards (NGSS) requires curriculum materials that integrate disciplinary core ideas, science and engineering practices, and crosscutting concepts. Given the costs—in both

time and money—of developing such materials, it will be years before high-quality materials exist that can help teachers make the NGSS vision a reality in their classrooms. In the meantime, what can the science education research community do to increase the supply of and demand for such materials? In this symposium three curriculum development groups will report on how their materials meet the criteria for alignment to NGSS and support for instruction as outlined by the recently released Educators Evaluating the Quality of Instructional Products (EQUiP) Rubric (Achieve, 2014). Each case study will (a) present an evidence-based argument to justify the development team's claim of the material's alignment to NGSS, (b) describe weaknesses in the material identified in the analysis, and (c) consider how the analysis findings could inform revisions to the material. The session will conclude with a synthesis of lessons learned from using the EQuIP Rubric and suggestions for improving the rubric's usability and value to the science education research community.

Strand 11: Cultural, Social, and Gender Issues
Engagement in Science Learning
8:30am - 10:00am, Grand Suite 5
Presider: Sara E. Tolbert, University of Arizona

Underrepresented Students' Interests and how they Relate to Engineering
Morgan M. Hynes, Purdue University
Avneet Hira, Purdue University
Cole Joslyn, Purdue University
ABSTRACT:
The research presented here is a sub-study within a larger design-based research study to develop and investigate how engineering challenges designed specifically to incorporate students' individual interests motivates their engagement in engineering. The data and findings presented in this paper are pilot results from an interview protocol designed to elicit students' personal interests and how the students perceive engineering and its relation to their interests. The four male students are entering grades 8-10 and are from underrepresented minority groups (3 African American, 1 Hispanic). The work is situated within a learning model that considers how learners' interests, values, and knowledge interact in the learning process. From this perspective, external or situational interests are distinguished from internal or personal interests. The findings reveal insights into how the four students from underrepresented minority groups describe their interests in interactive, hands-on science and engineering activities and how they may or may not relate to their personal interests and their desire to pursue engineering as a career.

Influencing Urban Students' STEM Interest through Informal Experiences in Geosciences
Geeta Verma, University of Colorado Denver
Jacqueline Leonard, University of Wyoming
Joy B. Johson, University of Wyoming
ABSTRACT:
In this paper, results from a two-year study known as Dinosaurs, Denver and Climate Change (D2C2) are presented. In the study, children (aged 8-12) participated in multi-aged groups to learn science within the context of paleontology and climate change. The goals of the project activities were to positively influence underrepresented students' interest in STEM. Professionals in geology and soil science implemented field-based lessons relative to their disciplines. Data analysis indicated that students' interest in science (and STEM related careers) was positively impacted. We conclude the D2C2 program was moderately successful in terms of its goals to develop STEM interest among elementary-aged underrepresented students.

Students' Perceptions of Science in Single-Sex and Coeducational Science Classes in the United States

Amber Simpson, Clemson University
S. Megan Che, Clemson University
William Bridges, Clemson University

ABSTRACT:
Recently, single-sex classes within public coeducational schools have proliferated across the United States; yet, we still know little about whether and how single-sex science classes influence adolescents' views of science as a male domain. This study investigates the extent to which adolescents associate science more closely to one gender than another among students enrolled in single-sex science classes as compared to students enrolled in coeducational science classes. Utilizing a quasi-experimental research design, findings suggest that boys enrolled in single-sex science classes have negative perceptions of themselves as science students, while girls, regardless of class type, perceived themselves as working hard and putting forth effort in order to be successful in science. Implications and future research will be discussed.

From Beavers to Bigfoot: Design-based Science Learning in an Informal Culturally Relevant STEM Program

Melinda Howard, University of Idaho
Anne Kern, University of Idaho

ABSTRACT:
Design-based science curricula can provide engaging alternatives to traditional science instruction while providing opportunities to learn complex systems by combining scientific inquiry with engineering practices(Hmelo et al. 2000). Culturally diverse learners, including American Indians, may benefit from design-based science curriculum, yet there remains a gap in the literature as to how this approach benefits culturally diverse learners. This is pertinent as tribal communities desire a greater inclusion of tribal representatives in tribal STEM positions. In response, a culturally-rich, place-based informal STEM camp was offered to youth from two regional tribal communities during the summer of 2013. Students participated in STEM activities that informed them of geomorphological and ecological issues leading to a design challenge of creating a stream restoration plan. Students built a three-dimensional model of a proposed stream restoration based on data collected in the field, tribal knowledge, and environmental engineering practices. The portrayal of STEM, cultural experiences, and camp themes on student representations of the stream restoration design will be discussed.

Understanding the Paradox of Chinese Learners: Insights from Research into Asian Chinese Science Learners

May Hung May Cheng, The Hong Kong Institute of Education
Zhi Hong Wan, The Hong Kong Institute of Education

ABSTRACT:
The excellent science performance of Chinese students has been consistently reported in large-scale international comparisons. However, these results seem to contradict with the Western typical descriptions of Chinese classroom learning environment and learners, which is called as the Paradox of the Chinese Learners. Although scholars have attempted to explain the paradox through the research into some general aspects of Chinese learners, there is still a lack of efforts to systematically summarize the findings from the research of Chinese science learners and their science learning so as to explain the paradox. This paper first summarizes the findings of empirical studies published in international journals on three related aspects of Asian Chinese school science learners, i.e., attitude towards learning science, science learning strategy, and scientific epistemological views. More specifically, these findings will cover (a) the status of Chinese science learners in these three aspects, (b) the relationship between these three related constructs and science achievement, and (c) the relationships among them. After then, efforts are made to utilize the summarized findings to generate hypotheses to address the paradox and suggest directions for further research.

Strand 11: Cultural, Social, and Gender Issues
Identity Development
8:30am - 10:00am, Water Tower
Presider: Justine M. Kane, Wayne State University

Lack of Opportunity, Achievement, and Choice? A Comparison of Math and Science Opportunity, Achievement, and Course Choice in Hispanic Males and Females
Stacy McCormack, Indiana University
Adam V. Maltese, Indiana University
ABSTRACT:
Although for years Hispanics lagged behind other racial/ethnic groups with respect to college enrollment, Hispanic students who have recently graduated high school are now exceeding college enrollment levels of white students (Author, 2013). Documented evidence of an 'achievement gap' has, however, demonstrated lower enrollments of minority students selecting career paths in math and science fields (Author, 2003). In the existing literature, a large difference exists between Hispanic males and Hispanic females with respect to courses taken and future plans (Authors, 1998). Hispanic females tend to take the lowest level courses while at the same time demonstrating the poorest attitudes toward math and science (Author, 1994; Author, 1982; Author, 1999). Would more recent data sources show the same documented gaps with respect to math and science now that college enrollment levels for these Hispanic students are increasing? This question was examined using data from the High School Longitudinal Study (HSLS) to determine if more recent data sources would replicate the same results as have been found previously or would demonstrate evidence of decreasing gaps with respect to opportunity, achievement, and choice between Hispanic males and females.

Understanding Student Perceptions About Physics: Finding Similarities and Differences Between Middle School Girls and Boys
Emily A. Dare, University of Minnesota
Gillian Roehrig, University of Minnesota
ABSTRACT:
This study examines the perceptions of 6th grade students regarding physics and physics-related careers. The overarching goal of this work is to understand similarities and differences between male and female perceptions about physics and how girl-friendly and integrated STEM strategies might affect these perceptions. This explanatory sequential mixed-methods study uses a survey and focus group interviews to understand the similarities and differences of girls’ and boys’ perceptions of physics and physics-related careers. Understanding these aspects may lead to the unearthing of what type of classroom culture fosters students’ interest and self-concept in physics.

Hispanic and White Students Perceptions of Scientists: Findings Using the Identify-a-Scientist (IAS) Instrument
Angela M Chapman, University of Texas - Pan American
Leon Walls, University of Vermont
ABSTRACT:
Providing all US students with equitable access to science has proven to be one of the most challenging issues in science education. Inequities have led to marginalization of students in science, which in turn has led to differences in science achievement between male and female students as well as students of color and White students. This, in turn, has contributed to an underrepresentation of females and students of color in science, technology, engineering, and mathematics (STEM) careers. While there are many reasons influencing students pursuing STEM careers, one specific factor is student perceptions of scientists. We report here on a large-scale study of Hispanic and White student perceptions of scientists using the Identify-a-Scientist instrument.
ABSTRACT:

British Muslim Girls' Dis-identification with Science: A Case Study of one English High School
Spela Godec, King's College London
ABSTRACT:
This paper discusses how British Muslim girls identify with science and what factors influence their identification and engagement with science. The paper responds to concerns about disengagement of young people with science and the inequalities in participation in science. This study draws on lesson observations, discussion groups and interviews with high school pupils (aged 11-13) in an all-girls urban high school in the North of England, their science teachers and their families. I discuss the tensions between an egalitarian discourse that anyone can do science and be good at it, and simultaneous dis-identification with science due to its association with traits perceived 'not like me'. I focus the disjuncture between family support for studying science and their discouragement from more 'demanding' science careers, whic they consider too difficult/not suitable for their daughters. This tension is explored through an interplay of science capital, gender and ethnicity, e.g. how students were encouraged (or not) to study science. This paper hopes to make a contribution to a better understanding of the tensions and complexities of gender, ethnicity and social class in shaping young people's identification and engagement with science.

Strand 12: Educational Technology
Science Teacher Education with Technology
8:30am - 10:00am, Columbus KL
Presider: Noemi Waight, University of BuffaloBuffalo

Implementing Technology and Visualization in Chemical Education: High and Middle School Science Teachers' Views
Shirly Avargil, Bar-Ilan University, Israel
Gabby Shwartz, Technion - Israel Institute of Technology
Orit Herscovitz, Technion, Israel Institute of Technology
Yehudit Judy Dori, Technion, Israel Institute of Technology
ABSTRACT:
Teachers' views and concerns regarding the implementation of technology and visualization in chemical education are related to different aspects of the teachers' knowledge. This study was conducted in the setting of the process of reforming high school chemical education, followed by a reform in middle schools' science education. One of the main aspects in the two reforms was establishing a technology-based and visualization-rich learning environment. The research goals were to examine teachers' views and concerns on teaching and learning chemistry in a visualization-rich environment. This goal is important in order to establish vertical alignment between middle school and high schools regarding learning chemistry. Eight high school teachers and five middle school teachers were interviewed for this study. Two of the science teachers were also observed while they taught in their classes. Analysis revealed a variety of teachers' views and concerns, which were divided into three categories: pedagogical content knowledge (PCK), technological pedagogical and content knowledge (TPACK), and assessment knowledge (AK). Overall, teachers had positive views, but also several concerns towards the visualization-rich environment. We recommend creating cross grades teachers' professional development for supporting teachers in challenges like implementing continually-evolving technology and finding pedagogical and assessment methods that combine digital materials.

Science Teacher Selection and use of Technologies: Implications for Implementation of Reform Technologies and Understandings of Evolution of Technology
Noemi Waight, University at Buffalo
Ming Ming Chiu, Professor, Educational Psychology, Purdue University

Melinda Whitford, University at Buffalo

ABSTRACT:
This study contributed to our understanding of those factors that serve as predictors of science teachers' selection and use of technologies and more specifically, how selection and usage was realized among teachers of different science disciplines. Notable descriptive statistics were examined, and we tested an explanatory model of how demographics, school context, pedagogical approaches and professional development influenced the likelihood of a teacher using a tool via a multilevel cross-classification ordered logit analysis (Goldstein, 1995). The findings revealed that science teachers were more likely to use hardware than software; and more specifically, this included instructional tools (i.e. SMART boards, clickers) and laboratory tools (probeware). Differences in teachers' use of tools were largely due to differences in tools as opposed to differences in teacher characteristics. Use of a tool was more likely by teachers who taught physics, who taught via inquiry, or who had more professional development with a tool. These findings have implications for conceptualization of selection and usage of technologies that enter the science education pipeline; which tools become sustainable in the science classroom; how technological take-up differs across science disciplines and how understandings of evolution of technology help us anticipate challenges associated with implementation of reform technologies.

Beyond TPCK: Exploring a Science Teacher's Technological Pedagogical Content Belief System

Mehmet Demirbag, Uludag University
Ahmet Kilinc, Uludag University

ABSTRACT:
Even though many teacher educators around the world benefit from Technological Pedagogical Content Knowledge (TPCK) framework in designing teacher education programs, we consider that this framework is relatively weak in terms of conceptual, epistemological and methodological perspectives. In the present study, after explicitly explaining our critics, we proposed an alternative framework - technological pedagogical content belief (TPCB) system - for understanding teachers' decision making regarding technology integration in subject-matter (science) education. This framework is based on belief theories and covers three types of beliefs (science, technology and pedagogy), the belief leakages among the pairs (science & technology, science & pedagogy, and technology & pedagogy) and TPCB that is produced by belief structures and leakages. In order to see how this framework works, we organized a deep, naturalistic single case study with an experienced science teacher (Ahmet). For uncovering belief structures and belief leakages, we conducted a series of semi-structured interviews. For investigating TPCB, we used the video-record of a science course into which Ahmet integrated several educational technologies. In the data analysis, we benefited from constant-comparative methodologies with iterative analysis processes. The results confirmed our assumptions about the suggested belief system model. In other words, the belief structures overlapped with each other via belief leakages and produced TPCB.

A Teacher's Appropriation of Educational Technologies

Shulamit Kapon, Technion – Israel Institute of Technology

ABSTRACT:
The work of an experienced physics teacher who started to teach physics at the advanced high school level in virtual classrooms (10th & 11th grades) was followed over a two year period. The goals of the study were to document and understand how this teacher used different technological tools in her instruction. Data include recordings of lessons, tasks, interviews, and research notes from informal discussions with the teacher. The teacher's exploration, integration, adaptation and creative usage of various educational technologies are theoretically modeled as a process of appropriation (Rogoff, 1995). The "hidden" instructional potential of these technologies are theoretically modeled as affordances (Gibson, 1986) that need to be discovered by the teacher. The ability of the teacher to see these affordances and to explore their potential use is cast as a hallmark of

professional knowledge of teaching. The implications for teacher education are discussed from the perspective of teachers as designers.

Strand 13: History, Philosophy, and Sociology of Science
Socioscientific Issues
8:30am - 10:00am, Grand A
Presider: Sibel Erduran, University of Limerick

Nature of Science Views and Argumentation Skills in the Context of Socioscientific Issues
Rola Khishfe, American University of Beirut
Fahad S. Alshaya, King Saud University
Saouma B. BouJaoude, American University of Beirut
Nasser Mansour, University of Exeter
Khalid Alrudiyan, Ministry of Education, Saudi Arabia
ABSTRACT:
This study examined students' argumentation skills and their understandings about NOS in the context of 4 controversial socioscientific issues with no intervention for NOS or argumentation. A total of 377 11th graders in 8 schools in Saudi Arabia participated in the study. Students responded to 4 scenarios that addressed controversial socioscientific issues about global warming, genetically modified food, acid rain, and human cloning. The four scenarios were followed by open-ended questions about argumentation and NOS. Data regarding participants' views of the NOS aspects (subjective, tentative, and empirical) and argumentation components (argument, counterargument, and rebuttal) were analyzed by using quantitative and qualitative measures. No significant correlations were found between the argumentation components and the 3 NOS aspects. Conversely, qualitative data from the open-ended questions showed that participants who generated well-developed arguments across the 4 scenarios exhibited more informed understandings of NOS, especially for female participants. Further, the $\chi 2$ analyses showed no significant differences in participants' argumentation skills and NOS understandings among the 4 scenarios while qualitative data showed differences in participants' responses to the scenarios. Results were interpreted along the framework of contextual and cultural factors. Implications for teaching of NOS and argumentation skills especially in Saudi Arabia were discussed.

Faith as Integral to Science! What Graduate Students "Saw" While Watching a Sci-Fi Film
John Y. Myers, University of Illinois at Urbana-Champaign
Fouad Abd-El-Khalick, University of Illinois at Urbana-Champaign
Jeanne Brunner, University of Illinois at Urbana-Champaign
ABSTRACT:
The Science and Engineering Indicators highlighted the importance for educational researchers to examine science fiction (SF) film because it tends to harm public understanding of science. We addressed this tendency in a recent study, particularly examining eleven doctoral students' film reviews and interviews regarding what ideas about science and epistemology they generated upon watching the SF film, Contact. The purpose of the present study is to look deeper into (1) what exactly ten of these eleven participants meant by one unexpected notion – namely, that they saw and sometimes believed that faith is a component of science – and (2) how this notion relates to any prior literature in history, philosophy, and/or sociology of science (HPSS) to establish any scholarly support. Participant ideas that scientific assumptions are faith-based were unsupported by prior HPSS literature. However, ideas that faith in religious doctrine is analogous to faith in scientific authority, and theory-choice in science can be faith-based, were shockingly corroborated by some HPSS literature. If SF film is used as a pedagogical tool, we encourage science teachers to promote open-ended reflection for students and discuss

any ideas generated by students, even those as intuitively paradoxical as faith in science, without reflexive criticism.

Nature of Technology and Informed Socioscientific Decision-Making

Hyun Ok Lee, Ewha Womans University, Korea
Dana L. Zeidler, University of South Florida
Sang Wook Yi, Hanyang University, Korea

ABSTRACT:
This study explores student conceptualizations of nature of technology (NOT) in the context of socioscientific decision-making about genetically modified food (GMF) and how the NOT may have informed decision-making. To delineate NOT conceptualizations on socioscientific decision-making, the authors suggested the functional NOT framework, as an analytical tool entailing four different dimensions: Technology as Artefacts, as Knowledge, as Processes and Role of Technology in Society. We collected data from forty-five college students enrolled in a liberal art course on science and technology studies about their decision making and justifications on a GMF issue. The data was analyzed using a qualitative methodology. The findings indicated that a range of concepts on three dimensions of NOT: Technology as Artefacts, as Processes, and Role of Technology in Society were present, and that NOT contributed to the participants' informed socioscientific decision-making.

Exotic Snakes and Hysteria in Florida: The Influence of Internet Social Media on Public Perception of a Socioscientific Issue

Samantha R. Fowler, Florida Institute of Technology
Michael S Grace, Florida Institute of Technology

ABSTRACT:
This study examined the relationship between Internet social media and socioscientific reasoning about the addition of four large python snakes to the injurious list of species under the Lacey Act of 1900. Thirty participants answered an open ended questionnaire, and nine participated in an interview. Results showed that while most tend to recognize that SSI are complex, they still did not have the tendency to utilize multiple perspectives to analyze the issue for themselves. Participants were also more likely to critique the credibility of sources related to information they disagreed with. Furthermore, whether or not an article concurred with one's beliefs was a large determinant in whether or information about exotic python snakes was shared on Internet social media. Results from our study indicate that beliefs affecting informed decision-making may be even more pronounced with the advent of social media. Due to the potential for rapid spread of misinformation through Internet social media, it is imperative that this topic be explored further.

Strand 15: Policy

Symposium - The STEM-ification of Science Education: Challenges for Policy and Practice in Neoliberal Times

8:30am - 10:00am, Columbus IJ

Discussant: Alberto Rodriguez, Purdue University

Presenters:

Alberto J. Rodriguez, Purdue University
Lyn Carter, Australian Catholic University
Lawrence Bencze, University of Toronto - Ontario Institute for Studies in Education
Matthew Weinstein, University of Washington - Tacoma Education Program
Chantal Pouliot, Université Laval
Ajay Sharma, University of Georgia

Michael Reiss, University of London
Deborah Tippins, University of Georgia

ABSTRACT:
In the contemporary era, Science-Technology-Engineering-Mathematics (STEM) has become part of the neoliberal discourse in K-12 classrooms, higher education and policy arenas. It is frequently invoked as the solution to preparing a future generation of youth with the capacity to solve our most urgent social and human problems. This symposium highlights examples of how neoliberalism is realigning science education to fit within a STEM discourse of national global competitiveness in ways which sublimate worthy goals of social justice and sociopolitical action. We consider the policy implications and challenges of navigating STEM education in neoliberal times and suggest that alternatives to neoliberalism will require a new moral language.

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

Strand 1: Science Learning, Understanding and Conceptual Change
Exploring Relationships Between Argumentation and the Development of Disciplinary Content Knowledge
10:15am - 11:45am, Columbus GH
Presider: Maria Pilar Jimenez-Aleixandre, Universidade De Sa

Embedding NGSS Science Practices in Digital Game-Based Genetics Materials: Measuring Content Knowledge, Argumentation, and Motivation
Frieda Reichsman, The Concord Consortium
Christopher Wilson, BSCS
April L. Gardner, BSCS
Trudi Lord, The Concord Consortium
ABSTRACT:
This paper describes the design, development, and testing of Geniverse: a game-based digital learning environment in high school genetics. Geniverse supports students as they learn crosscutting concepts and engage in science practices, performing experiments that generate data sets for scientific explanation and argumentation. This deep engagement with scientific argumentation helps students understand both science content and the process through which scientists learn about the world. Geniverse provides a set of interactive, game-like challenges that increase in difficulty, scaffolding students into a more genuine experience of scientific investigation. We studied the impact of these materials with a quasi-experimental research design involving 48 teachers – 24 using Geniverse and 24 using their business-as-usual genetics materials. Impacts on students' science content knowledge, argumentation skills, and motivation in science we compared. Results from hierarchical linear modeling analyses indicate that Geniverse led to significant gains on students' science content knowledge and argumentation skills. However, these gains were not significantly greater that learning gains in the comparison group. Our findings are discussed in light of other studies on game-based digital materials, and in the context of methodology for examining impacts of materials that are challenging to implement with high fidelity.

Coordinating Disciplinary Practices in Reasoning about Water Evaporation
Lama Jaber, Tufts University
Jessica Watkins, Tufts University
David Hammer, Tufts University
ABSTRACT:

NGSS places increased attention on engaging students in disciplinary practices. While there is extensive research on how students enter into and progress in particular disciplinary practices, there has been little attention on how they learn to coordinate multiple practices in an overarching pursuit of understanding phenomena. As an illustrative case, we examine an extended discussion of fifth graders investigating evaporation. For 25 minutes, students pursued deeper understandings about what evaporation is and how it happens. We show that they coordinate various scientific practices within this pursuit, including asking questions, using analogies to build models, and presenting evidence in arguments, all as they refine their ideas about evaporation. We argue that their orchestration of various disciplinary practices both emerged from and contributed to their collaborative pursuit of understanding evaporation. The students took up nascent forms of disciplinary practices as needed to clarify their ideas, reconcile inconsistencies, and explore mechanisms of evaporation. In turn, these practices sparked new questions and avenues of reasoning that fueled their engagement. The example, with others in the literature, supports arguments for cultivating disciplinary practices by first encouraging learners' curiosities and fostering their agency to pursue scientific questions.

A Comparison of Student and Teacher Argumentation and Conceptual Understanding
Deborah Lan, Ohio State University
Cathi Mehl, Ohio State University
Hui Jin, Ohio State University
ABSTRACT:
Argumentation is an important means to promote conceptual understandings. A deep understanding of science content is the foundation for the construction of high-quality arguments. In this study, we compare conceptual understanding and argumentation in high school students and secondary science teachers. We focus on energy consumption issues—how energy consumption activities such as transportation and using electricity affect the carbon cycle. We collected 10 teachers' written assessments and 30 students' clinical interviews. We modified a framework developed in a previous study (Authors, 2012) and used it to evaluate students'/teachers' conceptual understanding. Based on ideas from existing research of argumentation, we developed an argumentation framework to evaluate students'/teachers' understanding of the logical structure of arguments. We found although students and teachers demonstrated relatively good understanding of the logical structure of arguments, applying scientific knowledge to energy issues is challenging for both students and teachers. The results also suggest positive relationship between conceptual understanding and argumentation.

Strand 1: Science Learning, Understanding and Conceptual Change
Related Paper Set - Personally and Scientifically Meaningful Engagement in the Scientific Practices
10:15am - 11:45am, Grand D North
Presider: Yukie Toyama, University of California, Berkeley
Discussant: Charles Anderson, Michigan State University
ABSTRACT:
The National Research Council's Framework for K-12 Science Education and subsequently the Next Generation Science Standards cast scientific practices as a central goal for, and approach to, learning science. Envisioning science learning as participation in scientific practices requires that, rather than focusing on routines and knowledge of science as disconnected ideas to acquire, learners need to experience science as a purposeful, or meaningful, set of goal-directed activities. In this session we explore this hope that student work in the scientific practices be meaningful. In particular, we present two analytic lenses through which we can view the meaning that students imbue into their scientific endeavors in order to unpack the expectation that students will learn science by engaging in scientific practices. The analytic lenses emphasize two different communities that might find the students' work meaningful: meaningful to the scientific community and meaningful to the students in the classroom community. Thus, this session explores what it means to engage

students in scientific practices exploring the questions: How do we understand and support student engagement in classroom activities that are meaningful to the scientific and classroom communities? How do we understand student engagement in the scientific practices?

Students' Increasing Sophistication in their Mechanistic Responses
JinHo Kim, University of California, Berkeley
Yukie Toyama, University of California, Berkeley
Christina Krist, Northwestern University
Karen Draney, University of California, Berkeley
Brian J. Reiser, Northwestern University
Josh Sussman, University of California, BerkleyBerkley

The Content Generality and Specificity of Mechanistic Reasoning Across Middle-school, Model-based Explanation Assessment Items
Christina V. Schwarz, Michigan State University
Christina Krist, Northwestern University
May Lee, Michigan State University
Yukie Toyama, University of California, Berkeley

Why Ask Why If You Don't Care?: Relating Students' Mechanistic Moves To Their Purpose For Engaging In The Scientific Investigation
Leema Berland, University of Wisconsin-Madison
Heather Milo, University of Wisconsin-Madison

Co-evolution of Personally and Scientifically Meaningful Engagement
Lisa Kenyon, Wright State University
Jeannette Manger, Wright State University

Students as Brokers of Meaningful Knowledge
Christina Krist, Northwestern University

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Broadening the Scale: Learning and Capacity at Multiple Sites
10:15am - 11:45am, Comiskey
Presider: Erin E. Peters-Burton, George Mason UniversityUniversity

Exemplar Inclusive STEM High School Curriculum and Instruction: Cross-Case Analysis of Eight Schools
Erin E. Peters-Burton, George Mason University
Sharon J. Lynch, The George Washington University
Edmund M. Han, The George Washington University
Ann House, SRI International
ABSTRACT:
The desire for more interdisciplinary STEM curricula and reform-based STEM instructional practices is becoming increasingly tied to a push to increase the number of STEM-focused schools at all grade levels. Given the need for additional quality STEM schools in the United States and the evidence that many schools are far from this goal and require curricular and instructional reform to move in that direction, research on how successful STEM schools operate can help direct efforts for reform. In particular, information about inclusive

STEM high schools (ISHSs), those schools that do not have selective admissions criteria, is needed because most public schools share similar contexts. This study is based on a cross-cases analysis of eight exemplar ISHSs to elicit the ways these schools plan for and implement curriculum and instruction. Findings indicate that these schools have more rigorous requirements than their non-STEM peer schools, are smaller which affords flexible and creative scheduling, and successfully integrate content areas in different ways based on their resources. Hallmarks of instruction include systemic collaboration for both students and teachers, and a surprising variety of instructional delivery. This school-level study has implications for curriculum development, teacher preparation, and science education policy regarding STEM schools for all.

Comparing State-Mandated Outcomes of STEM and Traditional High Schools

Carol L. Stuessy, Texas A&M University
Niyazi Erdogan, Balikesir University
Dane Bozeman, Texas A & M University

ABSTRACT:
In answering the research question related to success of T-STEM in comparison with traditional schools, regardless of school type, female students performed better on reading scores whereas male students performed better on mathematics and science scores. In addition, White and Asian students outperformed all other ethnic groups on performance measures. Also, economically disadvantaged students and students in special education program were outperformed by students not identified as disadvantaged or learning disabled. Dropout rate negatively associated with students' reading, mathematics, and science scores, while percentage of students taking AP/IB end of course exam and SAT/ACT were positively associated. In conclusion, specialized STEM schools can be the solution to the problem of shortages in the STEM workforce; however, work still remains.

Exploring Professional Relationships about Science within K-8 Schools

Lara Smetana, Loyola University Chicago
Julianne A. Wenner, University of Connecticut
John Settlage, University of Conneticut

ABSTRACT:
There is a scarcity of information about school-level factors that are associated with student science achievement. This qualitative study builds on recent quantitative findings that reveal school-level factors that are significantly related to school-level science performance. Specifically, this study investigates teacher leader and school principal accounts of interpersonal trust in relation to their school science program. Participants were selected following statistical analyses of Grade 5 state science test scores and student demographic information. Interviews conducted with teacher leaders and school principals from positive outlier schools were conducted, and qualitative analysis followed a constant comparative approach. Findings offer insight into teacher-teacher, teacher-principal, and school-family relationships in these schools. Results reiterate the importance of a systems approach when considering potential avenues for improving science education and overcoming achievement gaps.

Cross-Sectional Study of Illinois Students' Attitudes toward Science

Ryan Summers, University of Illinois at Urbana-Champaign
Fouad Abd-El-Khalick, University of Illinois at Urbana-Champaign

ABSTRACT:
Affective variables, such as attitudes, play a major role in determining student engagement. Prior longitudinal studies indicate students' attitudes toward science decline over time. These trends are concerning as current research highlights students' disinterest in studying science and pursuing science-related careers. Many extant reports, unfortunately, have been narrow in terms of the grades surveyed and/or the diversity of students represented. This study employed a cross-sectional design to obtain a landscape view of Illinois students. A

statewide sample of 1700 students, grades 5 through 12, representing 90 schools completed an online version of the ASSASS instrument to measure their attitudes toward science. Additional information was also collected from the teachers of participating classes about their background, training, and attitudes. Data collected was used to (1) validate and refine the instrument; and (2) to identify patterns in Illinois students' attitudes toward science. A promising four-factor model was refined from exploratory factor analysis containing the following factors: positive attitudes, science ability, science intention, and science utility. The empirical factors were strongly correlated (0.3-0.8) and outperformed the theoretical model based on Akaike Information Criterion (AIC), Bayesian Information Criterion (BIC), Root Mean Square Error of Approximation (RMSEA), and the Goodness of Fit Index (GFI).

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Symposium - Toward Building a Foundation for Teaching and Learning in Elementary Science: Highlighting Six NSF Projects
10:15am - 11:45am, Columbus KL
Presenters:
Nancy Romance, Florida Atlantic University
Michael R Vitale, East Carolina University
Lynn A. Bryan, Purdue University
Ala Samarapungavan, Purdue University
Annemarie Palinscar, University of Michigan
Jonathan Osborne, Stanford University
Hilda Borko, Stanford University
Deborah L. Hanuscin, University of Missouri-Columbia
Carolyn Staudt, Concord Consortium
ABSTRACT:
Quality elementary science programs are faced with the challenge of adapting/building upon the NGSS (NGSS Lead States, 2013) in order to provide an essential foundation for student learning and interest in science. In meeting this challenge, researchers and practitioners alike must contribute toward the development of a knowledge base that identifies components that result in quality science teaching and student achievement. This session provides a forum through which NSF researchers addressing a variety of approaches for improving elementary science will discuss - with active audience involvement - how the ideas presented can contribute to the development of quality elementary science programs. While these projects use different tools and/or instructional models for doing so, all the projects are similar in that each addresses in some manner the following components: (a) Conceptual Models and Modeling, (b) Curricular Approaches Linking Science and Literacy, and (c) Specialized Models of Professional Development. Highlighted in the symposium will be implications for researchers and practitioners for systemic issues in elementary science education.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Exploring the Development of Teaching Assistants
10:15am - 11:45am, Grand Suite 5
Presider: Muhsin Menekse, University of Pittsburgh

How Students and Teaching Assistants Conceptualize the Purpose of Undergraduate Science Laboratory Courses
Stanley M. Lo, University of California, San Diego
Taylor R. Page, Northwestern University

Alyssa Haynes, Northwestern University
Shelby L. Hatch, Northwestern University
John C. Mordacq, Northwestern University

ABSTRACT:
Undergraduate laboratory education has been undergoing transformation in recent years to provide inquiry-based research experiences. While faculty may design activities with such a goal in mind, laboratory learning is often enacted between students and teaching assistants (TAs), who may not share the same goal. To date, no study has examined how students and TAs conceptualize the purpose of laboratory courses and what type of learning they expect to occur in such contexts. Especially in light of the recent calls to transform undergraduate laboratory education, it is critical to examine what student and TA expectations are and whether these expectations align with faculty intentions. In this study, we use a qualitative approach to explore how students and TAs conceptualize the purposes of biology and chemistry laboratory courses. We identify major expectations that students and TAs hold in relation to what they expect from the learning experience. Our preliminary data analysis suggests a mismatch between the national recommendations for transformation and expectations from students and TAs, who believe that laboratory courses serve to promote disciplinary content learning. Such a misalignment can potentially hinder meaningful learning in inquiry- or research-based laboratory courses that are focused on learning the processes of science.

Assessing a Professional Development for Teaching Assistants in a Project-Based Guided Inquiry General Chemistry Lab

Lindsay B. Wheeler, University of Virginia
Jennifer L. Maeng, University of Virginia
Brooke A. Whitworth, Northern Arizona University

ABSTRACT:
The purpose of this investigation was to explore changes in teaching assistants' (TAs) content knowledge, beliefs, and perceptions following professional development (PD). The PD was informed by the K-12 PD, TA training literature, and situated learning theory. It was designed for TAs implementing a project-based guided inquiry approach to general chemistry laboratory instruction and was evaluated using a sequential mixed-methods approach. Participants included 13 TAs. Data collection included surveys and interviews. Data were analyzed using t-tests and systematic data analysis. Results indicate TAs' content knowledge significantly improved following the professional development ($M=80.2\%$, $t(11)=2.20$, $p=.025$) and this improvement was maintained over the semester. By the end of the semester, the majority of TAs perceived their roles to include facilitating student learning and helping students act like scientists. TAs cited modeling, performing experiments, and discussing logistics as the most helpful PD components. TAs with no teaching experience and low content knowledge prior to the PD had more malleable beliefs compared to TAs with previous teaching experience. The results of this investigation suggest situated learning theory may be an effective PD model for TAs teaching reforms-based general chemistry lab courses.

Examining Biology Graduate Teaching Assistants' Beliefs about Teaching and Learning

Grant E. Gardner, Middle Tennessee State University
Tracie Addy, Quinnipiac University

ABSTRACT:
Within the college/university system of the United States, student attrition from STEM fields continues to be a challenge to the national goal of producing and retaining STEM talent. Reports demonstrate that some of this attrition is due to perceptions of poor instruction in STEM courses. Graduate Teaching Assistants (GTAs) are instructors that are in a position to teach large volumes of undergraduate students and yet are the least prepared to do so. Little is known about the teaching beliefs and practices of science GTAs. This study is a small portion of a larger case study examining the change of GTA beliefs about teaching and learning following course on

science instruction. Data from the Teaching Perspectives Inventory and Teaching Beliefs Interview and demonstrates that GTAs have high variance in their teaching beliefs but seem to be primarily transitioning to a more constructivist perspective of teaching and learning.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Learning Theory
10:15am - 11:45am, Water Tower
Presider: Jason R. Wiles, Syracuse University

Laboratory as Community: Equity and Efficacy with Reformed Instructional Practices
Joi P. Walker, Tallahassee Community College
Sherry A. Southerland, Florida State University
Victor D. Sampson, University of Texas at Austin
Patrick J. Enderle, University of Texas at Austin
ABSTRACT:
This study examines the influence of an ambitious laboratory teaching approach, that engages students in a wide range of the practices of science, on undergraduate students' chemistry learning. The examination was structured around a comparison of student learning in a setting that featured an ambitious instructional approach (in this case Argument Driven Inquiry—ADI, N = 81) and a laboratory featuring a Structured Instruction (SI, N = 76) and included an examination of the performance of women, underrepresented minority students, and low achieving students in each context. Student performance was assessed with a practical exam that targeted three specific scientific practices; experiment design and implementation, observation and inference and arguing from evidence. When it came to actually "doing" chemistry as measured by the practical exam, the students in the ADI treatment outperformed their SI counterparts. Students from under-represented minority groups, female and low GPA in the ADI section performed better than all students taught through SI. Additionally, underrepresented students in the ADI condition "closed the gap" with their majority peers, something not seen in the SI condition.

Flipped Classroom for Computer Science Undergraduates: The Effect of In-class Team Problem Solving and Projects
Yehudit Judy Dori, Technion-Israel Institute of Technology
Zehavit Kohen, Technion
Albert Meyer, Massachusetts Institute of Technology
ABSTRACT:
In our flipped classroom environment, in-class team problem solving replaces frontal lectures, which students are expected to watch at their own space and pace before each session. Implementing the flipped approach with problem-based learning, we assessed students' learning outcomes in the undergraduate Mathematics for Computer Science course. One of the main topics, probability, also included an optional team project element. The research questions were: (1) How do students' learning outcomes change in a flipped classroom throughout the semester? (2) Is there a difference in students' learning outcomes in probability between those who volunteered to take part in the probability project and those who did not? and (3) What were the perceptions of students engaged in team problem solving? The study, conducted during the academic year 2013-2014, included about 300 undergraduates who studied in the flipped classroom without or with the optional project. Research tools included pre-course questionnaire, mid-term and final examinations, and a feedback questionnaire. We found that all student scores improved significantly over time. The intermediate-level students improved the most, followed by the low achievers, and then by the high achievers. Students who conducted the probability project improved significantly more than those who did not.

Does Self-Assessment Engage Students in Metacognition? Challenges and Possibilities
Michael A. Gilchrist, University of Tennessee
Mehmet Aydeniz, University of Tennessee
Ross Toedte, University of Tennessee
ABSTRACT:
The purpose of this study was to explore whether self-assessment engages students in metacognition. 90 students who were enrolled in a college genetics course completed 10 self-assessment assignments over the course of one semester. Data consists of participants¹ responses to weekly self-assessments. We used the Natural Language Toolkit (NLTK) (Bird, 2006) to conduct our data analyses. Students¹ responses were evaluated around axes of complexity and lexicality to gauge level of metacognition. The sentence length, number of words and a metacognition variable that was defined by the authors were used to measure students¹ metacognition. The results show that while students were able to write complex sentences, this effort did not result in metacognition. Roughly 2/3 of participants did not receive a metacognitive score, based on the method used. Our discussion focuses on challenges in assessing students¹ metacognition and possibilities in using self-assessment to enhance students' metacognition.

More is Better: Student Centered Pedagogies Increase Student Learning in a Large Enrollment Biology Class
Deborah Donovan, Western Washington University
Georgianne Connell, Western Washignton University
ABSTRACT:
The evidence for using active learning pedagogies instead of lecture is overwhelming and studies comparing different pedagogies are needed. We compared learning gains and attitudes towards science in students learning biology in two different contexts: one in which the class was "flipped" and instruction included several student-centered active-learning strategies and one that relied on some active-learning strategies but was more teacher-centered. We offered two sections of Biology 101 during the same quarter. Both sections were taught by the same instructor and the same content was covered in each. We measured content knowledge with pre- and postassessments, as well as course exams. We measured student attitudes before and after the course using the VASS. We found that using several active-learning pedagogies in the student-centered section led to significantly greater content knowledge and more expert attitudes towards learning biology in students, compared to using fewer active-learning pedagogies in a more teacher-centered classroom. There are several pedagogies that we used in the student-centered section that we think were key to its success including group work on activities designed based on the basic tenets of constructivism, the explicit use of metacognition, and multiple forms of formative assessment.

Model Construction to Reveal Students' Conceptual Knowledge Retrieval in College-level Biology
Joseph Dauer, University of Nebraska - Lincoln
Tammy M. Long, Michigan State University
ABSTRACT:
One of the goals of college-level introductory biology is to establish a foundation of knowledge that can be built upon throughout a biology curriculum. In interviews conducted 2.5 years after a model-centric introductory biology, we examined students' retention of conceptual connections emphasized during the course and shown in student-constructed models. Student proficiency at model construction and their responses to conceptual questions were evaluated and grouped students into three distinct groups: students that had an inadequate cognitive structure for the biological concepts (absent), and students that had incomplete or complete cognitive structures that could be retrieved during the interview. Students in the Complete group were better able to verbally link the origins of genetic variation to phenotypic variation and differential fitness and successfully used relationships stored in their cognitive structure to explain gaps present in their drawn model. Students in

the Incomplete group had fragmented conceptual knowledge while the Absent group had extensive gaps in knowledge. More proficient students relied on a connected cognitive structure that allowed them to fill in knowledge gaps and suggests that teaching efforts should focus on connecting conceptual ideas so students can retrieve these connections and support continued learning.

Strand 6: Science Learning in Informal Contexts
STEM Out of School
10:15am - 11:45am, Roosevelt
Presider: Robert H. Evans, University of Copenhagen

Engineering Attitudes, Habits of Mind and Design Awareness in a Fab Lab MakerSpace Summer Camp
Aaron Price, Museum of Science and Industry, Chicago
Bryn Pernot, Museum of Science and Industry
Gloria A. Segovia, Museum of Science and Industry
Katherine Gean, Museum of Science and Industry
ABSTRACT:
Engineering education has a natural place in informal, out-of-school time spaces because it can be best addressed through flexible, open-minded experiences. “Fab Labs” are a type of maker space devoted to digital design and fabrication, usually through semi-structured programming. We studied seventeen children who attended a one-week summer camp at a museum-based Fab Lab. The children were given a pre- and post-test to measure changes in their engineering habits of mind, knowledge of engineering design components and engineering interests and attitudes. We also looked at covariates such as demographics, background in Do-It-Yourself projects and performance on engineering items taken from a state mandated standardized test. A control group was also recruited from another museum-based summer program. Results show no change in habits of mind or design knowledge, but there was an increase in engineering attitudes and interests.

Research on Impacts of an Electrical Engineering Summer Program for High School Students
Monica Bugallo, Stony Brook University
Angela M. Kelly, Stony Brook University
Minsu Ha, Kangwon National University
ABSTRACT:
Professional societies and industry have called for new approaches to engineering education that will produce more science, technology, engineering and mathematics (STEM) workers, while encouraging the development of an educational climate that will foster the goal of achieving STEM literacy for all. University educators and researchers designed and implemented a summer high school electrical engineering camp to address a major challenge in the U.S. – the need to build awareness and excitement for engineering career paths among secondary students. Pre- and post-assessments and surveys were administered to measure students’ knowledge and science self-concept. The quantitative data collection measured baseline proficiency variables, such as knowledge of the subject matter, along with social cognitive variables such as academic self-efficacy, valuation of competence, competence expectancies and subjectively perceived competence. Students demonstrated significant gains in engineering knowledge and perception of competence. They related engineering principles to their everyday lives, learned about engineering careers from faculty and industrialists, and became more interested in engineering as a result of participating in authentic tasks. This study provides a replicable model for innovative engineering learning, as well as collecting and interpreting data on program effectiveness.

Gender and Scientific Learning in a Design-Based Afterschool STEM Program
Jessica E. Schnittka, University of Colorado Denver

Christine Schnittka, Auburn University

ABSTRACT:
Collaborative, project-based instruction is often touted as the gold standard for increasing achievement and motivation for middle school students who would otherwise be uninterested in science, technology, engineering, and math (STEM). Research suggests however, that the effects of this type of instruction may not be distributed equally based on gender and socio-economic status. In the present study, videos of small group interactions in a design-based STEM afterschool program housed in the Appalachian Mountains were used to investigate how students navigate gender and social norms while becoming acculturated into the world of scientific inquiry. Multi-method qualitative discourse analysis was used to uncover several important findings. Results of this study will help practitioners design small group curricula that promote equity for all students regardless of socio-economic status and gender.

Investigating Impacts of One-day Activities in an Extra-Curricular Learning Laboratory on Students' Interest and Attitudes

Matthias Streller, TU Dresden
Yael Shwartz, The Weizmann Institute Of Science

ABSTRACT:
Based on a binational collaborative work several out of school activities have been investigated at an extra-curricular laboratory situated in a research center. The empirical evaluation follows an approach with pre- post-, and follow-up measurements. It investigates influencing features such as preparation and post progression at school as well as “laboratory features” characterizing the activities. To investigate the general outcome the generated interest is examined. According to this study, the extra-curricular learning laboratory achieved a high level of students’ interest. Furthermore significant differences were found regarding the majority of the “laboratory features”. Investigations of subgroups revealed further significant differences.

Strand 7: Pre-service Science Teacher Education
Approaches to the Design of Methods Courses
10:15am - 11:45am, Grand A
Presider: Eilish McLoughlin, Dublin City University

A Disciplinary Practices-Oriented Rationale for Science and Science Education Faculty Collaboration in Pre-Service Methods Courses

Tiffanyrose Sikorski, George Washington University
Hartmut Doebel, George Washington University

ABSTRACT:
In this talk, we provide a rationale and outline for a novel co-teaching approach to science methods courses, one that draws on the perspectives and expertise of science and science education faculty to engage teacher candidates as learners in inquiry and science practices. We articulate how the co-teaching approach can help teacher candidates learn to assess ideas according to criteria central to science, and to choose instructional best moves based on the content of those ideas, two central facets of learning to facilitate disciplinary practices in their own classrooms.

Investigating Pre-Service Teachers' Science Teaching Self-Efficacy While Participating in Field Experiences at a Science Museum: A Mixed Methods Study

Ratna Narayan, University of North Texas, Dallas
Lori Petty, UniversIty of Mary Hardin Baylor

ABSTRACT:

It has been reported elementary teachers have low science teaching self-efficacy and often avoid teaching science all together. Participants in this research study were 39 pre-service elementary teachers enrolled in a science methods class in the spring 2014 semester with a 20 hour field experience component at a new science museum. Bandura's theory of social learning lent itself well as the theoretical framework for the study. The research questions investigated what effect does a field experience at a science museum have on pre-service teachers' science teaching self-efficacy and what factors impact to pre-service teachers' science teaching self-efficacy while participating in a field experience at a science museum? Data consisted of pre / post surveys using survey monkey, course assignments, field experience reflections and focus group interviews. Data underwent constant comparison (Glaser & Strauss, 1967) and "theoretical questioning" (Charmaz, 2005, p. 511). The qualitative and quantitative data cohesively revealed participating in the field experience at the science museum affected participants' science teaching self-efficacy. Achieving success in their field experience helped participants confront and overcome their outcome expectancies with regards to science teaching in three broad categories; cultural, pedagogical and personal. Findings of this study have implications for teacher preparation programs.

Enhancing Science and Mathematics Teacher Education in Regional Australia: Evaluating an Enhancement Module for Science Pre-service Teachers

Geoff Woolcott, Southern Cross University

ABSTRACT:
This paper reports on initial evaluations of Enhancement and Feedback/Reflection Modules designed for pre-service teacher education in a project designed to enhance mathematics and science teacher education in regional Australia. Both modules utilize iterative processes with an overall objective of improving pre-service teacher performance through an investigation of the contribution of competence to confidence in teaching science. This paper reports specifically on qualitative assessments of the iterative process, with a focus on the effectiveness of the Enhancement Module. This module, along with an allied Feedback/Reflection Module, engages pre-service teachers, university scientists and specialist educators in targeted interactions designed to ground pre-service teacher education in regional contexts relevant to their daily lives.

Strand 7: Pre-service Science Teacher Education
Cultural and Equity Perspectives to Teacher Preaparation
10:15am - 11:45am, Randolph
Presider: Nazan U. Bautista, Miami University

Training Next Generation American and Cambodian Science Teachers Through Cultural Exchange

Gail L. Dickinson, Texas State University
Maureen Lemke, Texas State University
David Ford, Royal University of Phnom Penh
Heather Galloway, Texas State University

ABSTRACT:
This mixed methods study examines the perceptions and beliefs of American and Cambodian students involved in a summer science education program. This program described in this study is part of a longitudinal effort to transform science instruction in Cambodia to align with research-based practices. It is also an attempt to challenge American pre-service teachers’ ideas about multiculturalism and ESL in science instruction. To that end, eleven American undergraduate preservice teachers and nineteen Cambodian undergraduate science majors took science and methods courses together for three weeks at a Cambodian university. These courses emphasized argumentation from evidence and using local materials to conduct scientific inquiries. The courses culminated with a teaching experience at a local primary school. Findings indicate that both Cambodian and

American students benefitted from the experience. The experience significantly altered students' multicultural and egalitarian beliefs as well as reinforced the benefits of constructivist teaching methods.

Urban vs. Suburban Institutions: Preparing Science Teachers for Culturally Diverse Classrooms

Jacqueline Theresa Mcdonnough, Virginia Commonwealth University
Juanita Jo Matkins, College of William & Mary
Molly Madden Henschel, Virginia Commonwealth University

ABSTRACT:
This study discusses comparisons of urban and suburban Noyce programs at two public universities concentrating on preparing secondary science teachers for service in high-need schools. This study focused on self-efficacy beliefs and pedagogy reflecting culturally responsive practices, using quantitative and qualitative methods for data collection. Self-efficacy was measured using Siwatu's (2007) Culturally Responsive Teaching Self-Efficacy (CRTSE) and Riggs & Enoch's (1990) Science Teaching Efficacy Belief Instrument (STEBI). Pedagogy practices were analyzed using interview transcripts. This study found that there was a significant increase in self-efficacy beliefs for both universities from pre to post, but there were no differences between universities. Analyses focused on the final year also supported this trend; but there was a variation at the mid-point across programs. Additionally, researchers found there were no differences in outcomes between total and modified immersion teaching experiences. The teachers at both universities also reported instances of student-centered instruction and relevant approaches in their planning and instruction as well as culturally responsive teaching practices. Variances in teacher education programs, field placements in high-need schools, and support from classroom mentor teachers can impact the beliefs and practices of PSTs as they prepare for their first years of teaching.

Preservice Secondary Science Teachers Multicultural Perspectives about Students and Subject Matter

Sara P. Raven, Kent State University
Lisa A. Borgerding, Kent State University

ABSTRACT:
Diversity in the U.S. school system has increased dramatically over the last twenty years, and the population of students from non-English speaking households has risen faster than any other segment of the student population. Despite this increase in student diversity, the diversity of teachers has remained largely the same, creating a disparity that can lead to cultural misunderstandings in the classroom, which can affect working relationships and student performance. Although all content areas have the potential for these misunderstandings, science classrooms pose particular problems, as many of the discussions revolve around who does science, aspects of science, and how science relates to other disciplines. We sought to address these issues by assessing PSTs' multicultural awareness and acceptance using surveys and interviews over a series of two years. Using this information, we seek to answer the following research questions: What is the multicultural competency of PSTs at the outset and completion of the program of study? What elements of the program of study deepen their understandings of multiculturalism? And how do their in-field experiences affect their understanding of multiculturalism? Preliminary results suggest that PSTs least endorsed negatively worded sexual-orientation items, and most endorsed positive views of gender, class, and sexual equality.

Developing Professional Pre-Service Science Learning Communities Through Equity Focused Practice-Based Teaching

Imelda L. Nava, UCLA

ABSTRACT:
This study focuses on the development of a professional learning community for pre-service science teachers by enacting equity focused teacher practice in a teacher education program. The program has selected four core practices based on a teaching framework focused on equity and access. These core practices include: content

rigor, content discourse, equitable access to content, and classroom ecology. Given a secondary science urban classroom context, ten strategies aligned to the core practices are identified (Table 1). Classroom observations, instructional logs, video analysis, video-based instructional rounds, and peer feedback on classroom practice and student work are used to foster a professional community of learners.

Strand 8: In-service Science Teacher Education
Strand Sponsored Symposium - The Handbook of Research on Science Education: Implications for Inservice Teacher Education
10:15am - 11:45am, Columbus CD
Presenters:
Norman G Lederman, Illinois Institute of Technology
Charlene Czerniak, University of Toledo
Carla Johnson, Purdue University
Dana Zeidler, University of South Florida
Angela Calabrese Barton, Michigan State University
Edna Tan, University of North Carolina-Greensboro
Tara O'Neill, University of Hawaii-Manoa
Per-Olof Wickman, Stockholm University
Barbara Crawford, University of Georgia
Julie Luft, University of Georgia
ABSTRACT:
This session will focus on selected chapters in the newly released Handbook of Research on Science Education (Volume II) with specific implications for inservice teacher education. Chapter authors will discuss the major findings, implications, and directions for future research for the following topics: interdisciplinary science teaching, socioscientific issues, science education urban contexts, learning progressions, scientific practices, and teacher professional development.

Strand 8: In-service Science Teacher Education
Investigating Teacher and Student Outcomes in Science Education Initiatives
10:15am - 11:45am, Gold Coast
Presider: Kemal Izci, Necmettin Erbakan University

Pairing Lesson Analysis with Constructivism: Designing and Studying an Online Energy Course for Teachers
Susan M. Kowalski, BSCS
Betty L. Stennett, BSCS
Mark Bloom, BSCS
Anne L. Westbrook, BSCS
Pamela G. Van Scotter, BSCS
ABSTRACT:
The[course name removed in blinded version] project, currently in its fourth of five years, is advancing knowledge in the field of teacher professional development (PD) by merging two facets of PD that have hitherto been studied separately and testing hypotheses about the degree to which this pairing enhances learning and practice. These facets are structured constructivist experiences (enacted by the 5E Instructional Model) and experiences grounded in situated cognition learning theory (enacted by video-based lesson analysis process). Teachers reflect on research-based teaching practices in the lesson analysis process through Science Content Storyline and Student Thinking lenses. The research project tests longitudinal impacts on teachers' content

knowledge, pedagogical content knowledge, and teaching practices and students' content knowledge, contributing much needed data for future PD projects. The course is creative both in its grounding of PD in classroom experience and in its plan to motivate teachers by leveraging their sense of urgency and the growing scientific data and tools related to alternative energy resources. We also study which aspects of online environments are most effective for teachers. Data collected are informing both of the full revisions of the course and are helping address significant gaps in our understanding of online PD.

Teacher Pedagogical Framing in the Context of Teaching Climate Change

Anita Roychoudhury, Purdue University
Daniel P. Shepardson, Purdue University
Andrew Hirsch, Purdue University
Jignesh Mehta, Purdue University

ABSTRACT:
In this study we report our work with middle school teachers who taught climate change with a focus on the mechanism of it. Eleven teachers and their students participated in the study. We used the concept of framework used in media studies and constructed pedagogical frameworks that teachers used from their reflective inquiries and other classroom artifacts. This approach allowed us to determine what the teachers selected as salient features of their teaching strategies and their tacit theories. The various indicators of the pedagogical frameworks show how teachers attempted to address contextual and conceptual challenges. The connection between pedagogical frameworks and student learning will be shared and implications discussed.

Technology Implementation, Affect, and Assessment Scores: A Three-Year Study with 2300 Underrepresented Middle School Students

Margaret R. Blanchard, North Carolina State University
Catherine E. LePrevost, North Carolina State University
Dell Tolin, North Carolina State University
Kristie S. Gutierrez, North Carolina State University

ABSTRACT:
This research is a mixed-methods, 3-year study investigating the effects of science and mathematics teacher professional development (TPD) on teachers in two rural, low-income middle schools, and student learning of 2300 students on high stakes assessment tests in mathematics (grades 6-8) and science (grade 8). The 20 teachers experienced from 2-3 years of an inquiry-based, technology-infused TPD program supported by monthly online sessions. We investigated: the impacts of a technology-infused math and science intervention on teacher beliefs and practices; whether the mathematics and science assessment scores of students in project teachers' classrooms differ from those of students who are not; if the number of project teachers matters; whether assessment scores differ for Caucasian and African American students; and what teachers' reflections indicate about changes. There were significant increases in both the teachers' reform-based teaching beliefs and technology comfort, despite teacher-centered RTOP data. Students with more years of project teachers scored significantly better on assessments, with the most impressive gains for African American students and those with project teachers for 3 years. Teachers' pre/post reflections indicate that their use of technologies was transformative and that students had positive affective responses to using the technologies.

Evaluation of an Inquiry Professional Development Program: Student and Chemistry Teacher Outcomes

Stephanie B. Philipp, Miami University
Deborah Herrington, Grand Valley State University
Ellen J. Yezierski, Miami University

ABSTRACT:

A strong body of evidence shows that inquiry-based instruction helps students meet key learning outcomes including content, and process skills. Teachers want to improve their inquiry-based instruction, but often find short-term professional development (PD) programs ineffective. We have designed a PD program which incorporates what research has shown to be most effective in sustaining instructional change. To evaluate this program each academic year, we have collected student outcome data to measure growth in conceptual knowledge, scientific reasoning skills, motivation and self-regulation as well as teacher data, such as observations of instruction evaluated using the Reformed Teaching Observational Protocol. Nested data (students in teacher classrooms) were analyzed using hierarchical linear modeling. Results of our two-year evaluation will be presented along with implications for inquiry-based instruction and professional development programs for experienced teachers.

Strand 8: In-service Science Teacher Education
Symposium - Models of Practice-Based Professional Development in Support of Next Generation Science Standards
10:15am - 11:45am, Grand B
Presider: Erin M. Furtak, University of Colorado
Discussant: Scott McDonald, The Pennsylvania State University
Presenters:
Tana J. Peterman, University of Washington
Sara C. Heredia, University of Colorado, Boulder
William R. Penuel, University of Colorado
Angela H. DeBarger, George Lucas Educational FoundationFoundation
Andrew W. Shouse, University of Washington
Jessica J. Thompson, University of Washington
Karin Lohwasser, University of Washington
ABSTRACT:
Release of the Next Generation Science Standards [NGSS] has set forth an unprecedented move in science education reform toward large-scale adoption of a new framing for science teaching and learning. If this vision is to be realized in science classrooms, teachers will need access to high-quality, meaningful professional development experiences that position teachers as professionals who learn best in long-term settings that are situated in their classrooms. This symposium includes reports from four different research projects, each of which combines practice-based models of professional development and the ambitious reforms delineated by the NGSS. Each paper presents information about the professional development model on which it is based, empirical results related to the effectiveness of that model in teacher learning and classroom practice, and visions for future work in this area. Time will be allotted for synthesizing across the different models of professional development, and framing challenges for professional development in adoption of the NGSS.

Strand 10: Curriculum, Evaluation, and Assessment
Nature of Science / Philosophy of Science
10:15am - 11:45am, Columbus IJ
Presider: Avi Hofstein, The Weizmann Institute of Science

Characterizing Assessments Using the Three-Dimensional Learning Assessment Protocol (3D-LAP)
James T. Laverty, Michigan State University
Sonia M. Underwood, Michigan State University
Melanie M. Cooper, Michigan State University

Marcos D. Caballero, Michigan State University
Diane Ebert-May, Michigan State University
Joseph S. Krajcik, Michigan State University
Cori Fata-Hartley, Michigan State University
Rebecca L. Matz, Michigan State University
Lynmarie Posey, Michigan State University
Sarah Jardeleza, Michigan State University

ABSTRACT:
The President's Council of Advisors on Science and Technology recently noted, "The first two years of college are the most critical to the retention and recruitment of STEM majors." Our University has responded to these calls by approaching the transformation of the gateway courses in biology, physics, and chemistry using a process that focuses on scientific practices, crosscutting concepts, and disciplinary core ideas. As part of this transformation, assessments will need to be constructed that reflect these changes. We have developed the Three-Dimensional Learning Assessment Protocol (3D-LAP) to characterize assessments as part of the transformation effort. It has two purposes: (1) to characterize the extent to which formative and summative assessments are aligned with three-dimensional learning and (2) to guide the redesign of current assessment items to provide explicit evidence of student understanding. We demonstrate the utility of this protocol by using it to characterize the difference between exam questions, to characterize the difference between exams, and to help revise a previously existing assessment item. Additionally, we believe that teachers and assessment developers in K-12 could use the 3D-LAP to support the implementation of three-dimensional learning.

Exploring the Role of Facet-Based Items in Next Generation Science Assessment

Reina Fujii, SRI International
Angela Debarger, George Lucas Educational FoundationFoundation
Anna Werner, SRI International
Cynthia D'Angelo, SRI International
Mingyu Feng, SRI International
Kevin McElhaney, SRI International
Bowyee Gong, SRI International

ABSTRACT:
This paper examines the utility of facet-based assessments and their affordances in engaging students in schematic reasoning. Cognitive interviews were coded for students' use of goal (aligned to target facet) and problematic reasoning (not aligned), as well as for schematic knowledge and other types of knowledge (Shavelson et al., 2003). Findings show that all students used schematic reasoning when responding to the facet-based items. Cognitive interview data provide additional insight regarding the features of facet-based items that have the greatest potential to engage schematic reasoning. These findings can inform the construction of items that more fully elicit science practices, especially modeling and argumentation. While teacher implementation of facet-based assessments was not a focus of this paper, results also suggest that facet-based assessments may be useful in helping teachers orchestrate productive classroom talk related to the disciplinary substance of student ideas (Minstrell & Kraus, 2005).

Construction and Validation of the Views of Nature of Science-D (VNOS-D) Rubric

Julie Angle, Oklahoma State University
Sally Fenska, Oklahoma State University

ABSTRACT:
Creating a scientifically literate populace is a common goal among education stakeholders. An understanding of nature of science (NOS) is an important component of science literacy in K-12 science education. Some claim that open-ended questionnaires best identify the views individuals hold regarding various aspects of NOS. The

purpose of this study aimed to construct and validate a rubric that science teachers and science teacher educators could use to score the Views of Nature of Science-D (VNOS-D) questionnaire. Twenty-three science teachers, who also mentor students in science research and coach them in science fair competitions, completed the VNOS-D questionnaire. Participant responses were used to validate the VNOS-D rubric. Using a two-way ANOVA, absolute agreement among multiple raters, and across multiple participants was obtained. The 3-point scale was considered to have good and excellent inter-rater reliability, while the 5-point scale was considered to have excellent inter-rater reliability (IRR) for all nine aspects of NOS. Using a scoring system of 1 (Naïve), 2 (Emerging) or 3 (Informed) participants held mean scores that ranged from 1.22 (nature of scientific laws) to 2.03 (creative and imaginative nature of science) for all nine aspects of NOS.

Large Scale Hands-on Assessment of Experimental Competence in the Science Classroom

Andrea Moeller, University Trier
Doris Schmidt, University Trier
William Boone, Miami University

ABSTRACT:
The diagnostic of scientific inquiry competence, especially in the context of experiments, plays an important role in science education research. It is vital for further analysis of the nature of involved cognitive and psychomotor processes in order to develop targeted promotion of specific skills in the science classroom. In the here presented study we developed and evaluated a hands-on practical assessment of experimental competence that is based on theoretical models of scientific inquiry competence and meets the requirements for large-scale studies. The test instrument incorporates process based as well as status diagnostic approaches. On the basis of 52 test items in four predicted subskills “building up an experimental setting”, “conduct measurements”, “document data” and “identification of possible performance error”, assumed to be indispensable for conducting an experiment, 330 pupils grade 8 (age 12-14) performed in two previously unknown experimental settings. Detailed analyses of the test instrument suggest that it meets the relevant criteria and can be used to investigate pupils’ experimental performance competence. Overall, interesting patterns in pupils’ achievements in the four subskills can be observed and will be presented. Our study can thus help providing an assessment tool for individual promotion of experimental performance competence in the science classroom.

Developing Scientific Literacy And Supporting Post-Compulsory Science Participation: A Comparative Analysis Using National Data

Matt Homer, University of Leeds
Jim Ryder, University of Leeds

ABSTRACT:
In 2006 in England an innovative suite of science courses at 14-16 called Twenty-first Century Science (21CS) was introduced. These courses have a focus on developing scientific literacy in all students whilst simultaneously providing suitable preparation for the study of post-compulsory science for a smaller proportion of students. Using national data in England to track one cohort of students (n~370,000) over 2007-2011, this study compares progression rates to post-compulsory science courses in England between 21CS courses and non-21CS courses. Methods employed include simple comparisons of proportions progressing, and more complex statistical modelling to account for potentially differing student profiles in the two groups. We find that there is no overall difference in progression rates between the two types of 14-16 science course, but the modelling results find a small but consistently negative impact on progression of the 21CS course. Considering the research as a whole, we argue that our findings suggest that distinctive school science courses can help develop scientific literacy whilst also successfully supporting progression to post-16 science. It is important, therefore, for policy makers to afford sufficient curricular diversity in school science to allow this to happen.

Strand 11: Cultural, Social, and Gender Issues
Transformative Learning as Equitable Science Practices
10:15am - 11:45am, Grand Suite 3
Presider: Dorene R. Medlin, Albany State University

Acting for the Common Good: Incorporating Real Life Scenarios in Science Education; Lessons from Venezuela
Majd Zouda, University of Toronto
Tomo Nishizawa
John Bencze, University of Toronto
ABSTRACT:
In Venezuela, what started as an activist project to encourage affluent students to critically examine their consumerist values and take socio-political actions to address socio-scientific issues related to them has been magnified by sudden violent conflict throughout the country. Caught in the socio-political turmoil, students used activist science education to research resources available in Venezuela and take actions to propose innovative and more socially just ways to use them. This paper examines the type of socio-political actions taken by affluent Venezuelan students in this context and factors that appeared to affect their decisions. Our results suggest the (possible) effectiveness of using real life scenarios in activist science education to empower those with cultural capital to take an active role in providing solutions, while taking in consideration different cultural factors that may shape students' perspective of societal wellbeing.

Uncovering Sciencemindedness: Reality Pedagogy, Hip-Hop, & Urban Science Education
Christopher Emdin, Teachers College Columbia University
Edmund S. Adjapong, Teachers College, Columbia University
ABSTRACT:
Student culture has previously been suggested as the last unexplored frontier in reforming urban science education. Reality pedagogy has been birthed out of an understanding of hip-hop cultural dynamics, as well as the broader aim of culturally relevant science teaching for socio-political action. This phenomenological paper situates reality pedagogy in the context of a unique chemistry classroom and offers an exploration of the effects of implementing this pedagogical model with a population of students facing significant educational and societal challenges due to linguistic, socioeconomic, racial, and age-related factors.

Transitioning into Science Education: A Transformative Self-Study and Reflexive Approach to Understanding Equity
Francesca A. White, Indiana University
Gayle A. Buck, Indiana University
ABSTRACT:
What does it mean to be an equity-conscious researcher in science education? With the growing focus on equity in science education (e.g., Bianchini et al, 2013), greater attention is needed to how science educators/researcher make meaning of equity in teaching and research. In Gallard, Mensah and Pitts (2014), NARST members called for a “shared vision of equity for all” as science educators consider the implementation of the Next Generation Science Standards.The purpose of this transformative self-study was to unpack my (first author) taken-for-granted understandings of equity in science education. Findings include complexities with belonging and professional identity, tensions with voice, positionality in research and teaching, responsibility/accountability to equity, and approaching equity with empathy. Self-study can be a beneficial approach for individuals to make visible and (re)frame how we come to understand equity and move toward a common vision of “equity for all” in science education.

Assessment Practices and Scientific Identities in and Agroecology Course: A Case Study
Christopher D. Murakami, University of Missouri-Columbia
Marcelle Siegel, University of Missouri-Coluimbia
ABSTRACT:
Examining and enacting equitable assessment practices in science education is a way for researchers and instructors to become agents who are restructuring classrooms and research methodologies to meet the diverse needs of learners. Research on equitable assessment and critical science education places value on understanding and supporting marginalized learners' scientific identity formation. However, there is the need to better understand features of classroom assessments that shape and describe scientific identities. Using situated learning theory and communities of practice, this case study explored the features of assessment practices that support scientific identities in an interdisciplinary, Socio-Scientific Issues based, Agroecology course at a large Midwestern Land Grant University. Participants in the study included thirteen undergraduate students and five professors from agricultural science disciplines. The course and assessments were designed to give learners practice making decisions that balanced values of environmental responsibility, social justice, and economic viability in a variety of regional farming contexts. After analyzing the stories and experiences of learners in the course, we believe that (1) allowing flexibility, (2) sharing authority, and (3) supporting voices through assessment practices played a role in learners' agroecological identity formation. We discuss the challenges and affordances of enacting these three principles of equitable assessment in science education.

Engineering Rainbows and Unicorns: A Critique of the Next Generation Science Standards
Alberto J. Rodriguez, Purdue University
ABSTRACT:
In this paper, I offer a critique of A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas (NRC, 2012) and of the Next Generation Science Standards (Achieve, 2013). While the new version of the science education standards and the arguments put forward to support them are an improvement from the previous version of the NRC Science Education Standards, we must pause and reflect on the implications on jumping on another education reform, fast moving train. Using sociotransformative constructivism as a guiding theoretical lens, I argued that the Conceptual Framework and NGSS documents fall short due to the lack of retrospection, the on-going contradictory discourses, and the lack of voice and representation in the development of these important policy documents. Suggestions for improvement and discussion are offered in hope that we might prevent the NGSS from having as little impact on teachers' practice and on students' learning as the previous version of the national science education standards had.

Strand 13: History, Philosophy, and Sociology of Science
Strand Sponsored Symposium - International Perspectives about the Nature of Science
10:15am - 11:45am, Wrigley
Presenters:
Judith S. Lederman, Illinois Institute of Technology
William F. McComas, University of Arkansas
Meshach Ogunniyi, University of the Western Cape, South Africa
Kathy Saunders, University of Waikato, New Zealand
Hernan L. Cofré Mardones, Universidad Catolica de Valparaiso, Chile
Irene Neumann, Leibniz Institute for Science and Mathematics Education, Germany
M. Fatih Tasar, Gazi Universitesi, Turkey
ABSTRACT:
Understandings of nature of science continues to be a concern for science education. This is evidenced in the prominent role it holds in various reform documents throughout the world. Although there is universal

agreement about its importance, nature of science is not conceptualized in a universal manner, nor is it integrated into the more "traditional" science subject matter in the various reform documents. This symposium brings together researchers of nature of science representing five continents to share current thinking about the teaching of NOS from their countries' perspectives. The discussion will engage the audience in a productive and transformative dialog about the enduring construct of nature of science.*Improving Students' Understanding of Nature of Science through Reflective-contextualized Socioscientific Issues Instruction*Yoonsook Chung, Ewha Womans UniversitySung-Won Kim, Ewha Womans University**ABSTRACT:**The guiding research question was as below: 1) to what extent students develop their understanding of NOS? 2) To what extent SSI contexts contributed to promoting students' understanding NOS? A total of seventy one students (11th graders) participated in this research. The SSI program was developed to cover the issues of genetically modified organism, global climate change, and nuclear energy. Each issues required 4 to 6 class periods to complete. The overall process of SSI program was as follows. SSI program consists of three steps: Introduction, explicit-reflective Nature of Science learning, and decision making. The students were asked to evaluated claims of each article, analyze the evidences, or examine the credibility. Such request was intended to encourage students to reflect their own view on NOS and to make connections between SSI and NOS. The teacher encouraged students to confront their core beliefs on science during all the classes. Data were collected by pre and post VNOS-C test, interview, activity sheets. The researcher developed rubric inductively to evaluated students' answers according to cross case analysis. Students' NOS conceptions were compared by Wilcoxon signed rank test and chi square test. As a result of this program, students showed moderately improvement in their understanding of NOS. Students view on the empirical nature of science, tentativeness of science, and social-cultural embededded were significantly improved. The students were able to apply NOS conception from one SSI context to the other SSI context even though they could not transfer NOS concept from general context to SSI context.

Strand 14: Environmental Education
Culturally Embedded Environmental Education
10:15am - 11:45am, Columbus EF
Presider: Michelle Cotterman, Vanderbilt University

'Women Are the Saviors': Exploring Gender Issues in Environmental Resource Management

Cassie Quigley, Clemson University
S. Megan Che, Clemson University
Stella Achieng, University of Nairobi
Sarah Liaram, Maasai Mara National Preserve

ABSTRACT:
Although women account for almost 80 per cent of the agricultural sector in Africa are largely, historically, and currently absent from decision-making processes around issues of environmental degradation and its consequences (Denton, 2002). Women from less developed countries are often omitted from policy debates on environmental issues (Lambrou & Paina, 2006). It has been well documented that women in particular play a key role in environmental and natural resource management (Paavola & Adger, 2006; Thomas & Twyman, 2005). Thus, this study explored gender issues utilizing a qualitative critical feminist methodology employing thematic coding of focus group interviews. The themes were blame, responsibility and struggles with empowerment. Inequitable, asymmetric power relations between women and men can contribute to women's differential access to environmental resources and opportunities for economic advancement, causing increased environmental vulnerability and security. Environmental management continues to be an area that has critical impacts for women; therefore conservation should also take into account the gendered boundaries of labor in order to achieve greater equity (Sokona & Denton, 2001).

Influence of Nollywood Film on Students' Learning Outcomes on Global Warming and Ozone Layer Depletion

Michael Ahove, Lagos State University
Peter A. Okebukola, Lagos State University
Olatunde Lawal Owolabi, Lagos State University

ABSTRACT:
Learning outcome has continued to be a major concern for educators, researchers and the need for learners to attain metacognition in this technology driven generation is required now than ever. This study seeks to experiment the use of Nollywood film in a constructivist class spiced with cooperative learning technique to positively influence learners' outcomes. The important question this paper seeks to answer is; will Nollywood film significantly influence students' attitude, achievement, gender, willingness to act, and perceived personal towards global warming and ozone layer depletion? Mixed approaches of quantitative and qualitative methodologies were adopted in this study. The study employed a 2-group pre-test treatment post- test quasi-experimental design. Intact classes made of 209 (102 male and 109 female) grade 10 and 11students from 5 different high schools were selected. Result did not indicate that Nollywood had favourable outcomes this may be linked to favourable entry behaviour for some students in the control group. Science educators and especially the NARST community would find this study worthy of bridging the gap in literature of emerging studies on climate change in a diverse multicultural setting. Furthermore, misconception in science appears to remain strong, irrespective of the potency of the learning method.

Rural Science Education: Promoting Environmental Awareness Through Informal Science Education

Stanton G. Belford, Martin Methodist College
Melody Russell, Auburn University

ABSTRACT:
The use of informal science education (ISE) in rural areas, specifically at middle schools has not been well documented. Rural areas are more accessible to outdoor learning environments compared to urban areas, however teachers are less likely to incorporate informal activities into their curriculum. The research study investigated two life science teachers and 135 students. A case study strategy was used, which incorporated questionnaires, surveys, classroom observations, student artifacts, and teacher interviews to evaluate their perspectives towards informal science. Both teachers interest in informal science initially came from their parents. In fact, fathers played the greatest role towards initiating interest in ISE activities such as, visiting museums, gardening, farming, bee-keeping, and other outdoor activities transferred to the science interests of the two life science teachers in this study. Students showed a significant increase in environmental literacy knowledge (ELK) scores after the implementation of the informal science related curriculum. There was a significant increase for female ELK scores, but not for SK scores. Overall, this study showed that two 7th grade life science teachers with life changing informal science experiences, displayed positive interests in using a water monitoring curriculum designed for outdoor learning.

Designing an Environmental Science Curriculum in Bhutan

Sameer Honwad, University of New Hampshire
Shivaraj Bhattarai, Royal Thimpu College, Bhutan

ABSTRACT:
Learning to make decisions in everyday life that lead to environmental sustainability will allow communities to cope with current impacts and shape future ones. Literature in environmental adaptation suggests that environmental decision-making that would help mitigate the impact of climate change and help communities adapt to the changing environment requires that individuals: 1. Learn that everyday actions (eating breakfast, using technology, washing clothes etc) are interactions with the environment 2. Understand that everyday

actions/decisions have an impact on the environment at a local, national and international level and 3. Understand that the long-term impact of these actions/decisions is an important aspect of how one can adapt to the changing environment. Using the three points mentioned above this study examines how youth in the Bhutan Himalayas understand the environmental decision-making process. The study examines the processes of environmental decision-making through the lens of education/learning and comments on the improvements required in formal environmental sciences/education curriculum so that young people can reflect on the decision-making processes, understand how to mitigate the impact of climate change and adapt to the changing environment. The study seeks to address the deficiency in the literature for environmental decision-making processes from a learning and education perspective.

Concurrent Session #5
1:15pm – 2:45pm

Program Committee Sponsored Session
Symposium – NARST Proposal Submission and Review Process
1:15pm - 2:45pm, Columbus CD
Presiders:
Valarie L. Akerson, Indiana University
Mary M. Atwater, University of Georgia
Presenters:
Heidi B. Carlone, University of North Carolina, Greensboro
Michelle A. Fleming, Wright State University
Carla C. Johnson, Purdue University
Judith S. Lederman, Illinois Institute of Technology
Toni A. Sondergeld, Bowling Green State University
Cassie Quigley, Clemson University

International Committee Sponsored Session
Symposium – Promoting Cross-Culture Science Education Research
1:15pm - 2:45pm, Grand A
Presider: Hsiao-Lin Tuan, National Changhua University of Education, Taiwan
Presiders:
Sibel Erduran, University of Limerick, Ireland
Ebru Kaya, Bogazici University, Turkey
Pinar Seda Cetin, Abant Izzet Baysal University, Turkey
Audrey O'Grady, University of Limerick, Ireland
Keelin Leahy, University of Limerick, Ireland
Alphonse Uworwabayeho, University of Rwanda, Rwanda
Vedaste Mutarutinya, University of Rwanda, RwandaRwanda
ABSTRACT:
The purpose of this session is to present the various issues can be explored and ways to conduct cross-culture science education studies. The first paper will focus on using Linking Science Educator Project to bring resource from NARST to Rwanda, and helping Rwanda science educators to develop a preservice teacher training program in Rwanda. This study addressed on exploring the impact of a training program on argumentation on Rwandan pre-service teachers? perceptions of argumentation. The second paper addressed a five-year cross-culture project entitled EQUALPRIME, which addressed on understanding of teaching and

learning in primary science classrooms in Taiwan, Germany, and Australia. Researchers from the above countries conduct case studies of primary science teaching in their cities. They will share the research methodologies and understanding of the dynamics and complexity of education systems and processes. The third presentation will introduce cross-culture project entitled Science Education for Diversity which is a collaborative project between the UK, the Netherlands, Turkey, Lebanon, India and Malaysia. They will present finding on understanding how the partner countries address the issue of diversity and the improvement they can use for students science attitude and learning in Western and non-Western countries involved in the Project.

Re-Capturing Pedagogical Practice in Science Classroom from a Cross-cultural Comparative Perspectives
Chao-Ti Hsiung, National Taipei University of Education, Taiwan
Hsiao-Lan Sharon Chen, National Taiwan Normal University, Taiwan
Joerg Ramseger, FreieUniversity of Berlin, Germany
Russell Tytler, Deakin University, Australia
Mark Hackling, Edith Cowan University, Australia

The Science Education for Diversity Project: An International Collaborative Research Project
Saouma BouJaoude, American University of Beirut

Strand 1: Science Learning, Understanding and Conceptual Change
Related Paper Set - Lowering the Threshold - New Approaches to Teaching and Learning Evolution
1:15pm - 2:45pm, Columbus EF
Presiders:
Lena A. E. Tibell, Linköping University
Ute Harms, Leibniz Institute (IPN)
ABSTRACT:
The theory of evolution is considered to be one of the most groundbreaking theories in science and essentially underpins all modern biology. Science education research has shown that the theory of evolution presents severe problems to learners and many teaching strategies have been proven to be inefficient to solve these. The aim of our contribution is to propose new approaches for teaching and probing students' understanding of evolution. The first two studies focus students' pre-knowledge and conceptions regarding evolutionary theory. We present results regarding the influence of pre-knowledge for learning with worked examples and how differing representational modes reveal different student conceptions. The following three contributions stem from the assumption that the understanding of abstract threshold concepts (such as randomness, probability or temporal scale) is essential in order to grasp evolutionary theory. In this context, a criteria catalogue is presented including threshold concepts for the assessment of animations explaining evolution. Finally, a novel computer tool for teaching evolutionary mechanisms using visual analogies of randomness and natural selection as well as a first round of results from an intervention study focusing on the impact of understanding randomness for the comprehension of evolution theory is presented.

A Criteria Catalogue Covering Multiple Evolutionary Aspects Including Threshold Concepts for Assessment of Animations Explaining Evolution
Gustav Bohlin, Linköping University
Jennifer Härting, Leibniz Institute (IPN)
Ute Harms, Leibniz Institute (IPN)
Lena A. E. Tibell, Linköping University

The Impact of Understanding Randomness in the Comprehension of Evolution

Ute Harms, Leibniz Institute (IPN)
Ann-Christin Lühr, Leibniz Institute (IPN)
Jennifer Härting, Leibniz Institute (IPN)

A Novel Computer Application for Teaching Evolutionary Mechanisms: Visual Analogies of Randomness and Natural Selection

Andreas C. S. Göransson, Linköping University
Jörgen Stenlund, Örebro University
Lena A. E. Tibell, Linköping University

How Are Conceptions of Adaptation Expressed in Different Representational Modes?

Daniel Orraryd, Linköping University
Lena A. E. Tibell, Linköping University

Learning Evolution Using Worked Examples and Considering Students' Prior Biological Knowledge

Charlotte Neubrand, Leibniz Institute for Science and Mathematics Education (IPN)
Ute Harms, Leibniz Institute for Science and Mathematics Education (IPN)

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Issues of Argumentation in Science Learning
1:15pm - 2:45pm, Columbus AB
Presider: Brian M. Hand, University of IowaIowa

The Influence of One Teacher's Framing and Instructional Actions on Students' Scientific Argumentation

Jennifer Schellinger, The Florida State University
Shannon Gooden, The Florida State University
Jonathon Grooms, The Florida State University
Martin Bremer, The Florida State University
Victor D. Sampson, The University of Texas at Austin
Patrick J. Enderle, The University of Texas at Austin

ABSTRACT:
The framing and instructional strategies that teachers use to support scientific argumentation in the classroom should allow students to construct, critique, and evaluate evidence-based claims through collaborative, social discourse, and dialogic processes that make their thinking visible. This study presents an in-depth look at how the framing and instructional actions employed by one ninth grade biology teacher influenced students' generation and evaluation of scientific arguments over one school year. Results suggest that framing and instructional actions that follow closely with the discursive practices of science and positioning students as active producers and assessors of knowledge may not be enough. Students in this study experienced minimal growth in argument generation and evaluation and, although, their teacher's framing and instructional actions were learner-centered they did not effectively employ modeling and scaffolding strategies that may foster students' growth in argumentation. Students and their teachers should be afforded time and practice in argument-focused investigations, as teachers may need iterative professional development that allows time to reflect and build their understanding of instructional strategies and classroom norms to support students' engagement in argumentation.

Promoting Elementary School Students' Attitude toward Science and Argumentation through a Science Inquiry Intervention

Zuway-R Hong, National Sun Yat-Sen University
Hsiang-Ting Chen, National SunYat-sen University
Hsin-Hui Wang, National SunYat-sen University
Ting-Yi Tsai, National SunYat-sen University
Ying-Yan Lu, National SunYat-sen University

ABSTRACT:
This study was to investigate the effectiveness of improving elementary school students' attitude toward science and argumentation through a science inquiry intervention. A total of 119 4th graders (60 boys and 59 girls) participated in the study. Thirty-six 4th graders volunteered as an experimental group (EG) to join 12-week science inquiry intervention; 83 4th graders volunteered to be the comparison group (CG). All participants completed the Student Questionnaire (SQ) at the beginning and end of this study. In addition, 8 target students (TS) from the EG were recruited to be weekly observed and interviewed. Exploratory Factor Analyses (EFA) and reliability analyses were conducted to assess the development and validation of SQ, analyses of covariance, and content theme analyses assessed the similarity and differences between the EG and CG. It was found that the EG students' total scores on attitude toward science and argumentation significantly outperformed than the CG; additionally, their negative affection in learning science was significantly lower than the CG. Interviews and observations indicated that EQ students' attitudes toward science and quality of argumentation changed over the intervention. Implication and educational recommendation are discussed. Key words: science inquiry intervention; attitude toward science; argumentation; elementary school students; Taiwan

The Impact of Argument-Based Classroom Teaching on Student Multimodal Competency

Nurcan Keles, University of Iowa
Mark A. McDermott, University of Iowa
Brian M. Hand, University of Iowa

ABSTRACT:
The purpose of this study was to examine the impact of argument-based inquiry on the development of multimodal competency as exhibited by measures of integration in multimodal products. For this purpose, a quasi-experimental design was utilized with 355 student writing samples from 17 classes being coded. Treatment students were in classes that used the SWH argument-based inquiry approach while control classes did not use the approach. Findings suggest in grades 4 and 8, students in SWH classrooms not only used more modes and were better able to apply strategies to link specific alternative modes to nearby text, but also created more cohesive overall products. In Grade 7, although non-SWH students utilized more modes and were better able to link individual modes to nearby text, SWH students created more overall cohesive products. This study indicates that argument-based inquiry may impact multimodal competency development, but strategy use associated with effective embeddedness (linking individual modes to nearby text) may not develop simultaneously with strategy use for cohesiveness. Finally, as evidenced by the findings here, students at different grade levels may develop multimodal competency in different ways.

How Does Argumentation from Data Differ when Students Work with Real vs. Virtual Experiments?

Tobias Ludwig, Humboldt University of Berlin
Burkhard Priemer, Humboldt University of Berlin

ABSTRACT:
Argumentation from data and evidence evaluation are widely seen as scientific core practices. Consequently, science educators became aware of these topics, especially in the past two decades. But up until now, there has been little research done on analyzing the influence of the source of the data in students' argumentation. One widespread source of experimental data and observations is computer simulations, since they become more and more available in school laboratories and are widely used in educational research as an efficient method to assess students' behaviour during experimentation. We argue that, from an epistemological perspective, the

application of computer simulations instead of real hands-on material is not sufficiently justified. Accordingly, this paper presents the findings from a randomized, experimental study among 911 secondary school students examining a) the influence of the learning environment (real vs. virtual experiment) on students' argumentation from data and b) the influences of personal factors (situational interest, personal relevance, need for cognition and content knowledge) on given types of argumentation, as theoretically predicted by different models in the field of communication psychology. This work contributes to a better understanding of argumentation from data and observations in school labs and learning of sciences through experimentation.

Scrutinizing the Positions of Students and Teacher in Argumentation in a High School Physics Classroom

Jianlan Wang, Florida International University
Gayle A. Buck, Indiana University

ABSTRACT:
Scientific argumentation is a critical skill for science learners. Despite its significance, argumentation rarely occurs in science classrooms. In this case study, my focus dealt with understanding how teachers and students perceive argumentation innovations. I used the positioning method to gauge the relational process of argumentation in a high school physics classroom. Through scrutinizing the positions of a physics teacher and 24 high school students, I closely examined the ways in which individual variation resulted in classroom communities adopting and evolving the argumentative practices. After summarizing the patterns of positions that stood out, I constructed a dynamic model of argumentation. Based upon this model, argumentation was impacted by inner factors in terms of arguers' properties and outer factors in terms of the nature of an argumentation task. With this model, I compared the differences between authentic argumentation among scientists and the argumentation observed in the physics class. These differences shed light on the reasons for the incompatibility of authentic argumentation in a classroom context. Finally, I suggested a student-friendly pattern of argumentation as the solution for bridging the gap between the theoretical importance of argumentation and its insufficient practice in science classes.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Examining Power and Relationships among Young Science Learners
1:15pm - 2:45pm, Randolph
Presider: Li Ke, Michigan State University

The Discursive Construction of Relationships Between Science and Fantasy-Magic-play in an Elementary Classroom

Elaine S. França, Centro Pedagógico (1-9 grades school) - Universidade Federal de Minas Gerais
Luiz Gustavo F. Franco Silveira, Universidade Federal de Minas Gerais
Vanessa Capelle, Universidade Federal de Minas Gerais
Danusa Munford, Universidade Federal de Minas Gerais

ABSTRACT:
In this study,to understand how relationships between science and fantasy-magic-play,we examine interactions in an elementary classroom, during science lessons. We conducted participant observation with video and field notes recording throughout two years. We analyzed events in which the group negotiates these relationships, when knowledge related to these contexts emerged, and how the teacher act in these situations. We adopted an ethnographic perspective, informed by interactional ethnography, interactional sociolinguistics, and microethnography. The analysis evidenced how there are recurrent aspects that are present in the ways the group interacted as a whole class. Throughout the two years, for instance the teacher poses questions to students, as well as they relied on their memories/experiences to engage in discussion that addressed relationships between science and fantasy-magic-play. At the same time, changes took place. For instance, the

teacher introduced more directed questions, gradually requesting for a positioning, and problematizing conceptions students held. The recurrent patterns indicate that the group relied on cultural practices to build new understandings and engage in new practices.

Mediating Hierarchies in a Science Specialist Model: Science Culture in Urban Elementary Schools
Darcy M Ronan, Teachers College, Columbia University
Felicia Moore Mensah, Teachers College, Columbia University
ABSTRACT:
This study sheds light on a widely used but rarely studied instructional model, the elementary science specialist. This ethnography describes and analyzes the implementation of elementary science specialists in urban elementary schools in a high-stakes testing climate. School and district factors that affect the enacted science specialist model are identified and critically analyzed. In addition to widely discussed teacher-centered factors, these school and district structures establish, perpetuate and/or work against the unquestioned institutional hierarchies, with intended and unintended consequences. The hierarchies of Core over Enrichment and Tested over Untested mediate and are mediated by the science specialist structure implemented at a given school site, impacting the science culture of the school.

Every Day, Every Child: Investigating Models of Science Specialization among Elementary Teachers
Joseph A. Brobst, Western Washington University
Kimberly Markworth, Western Washington University
ABSTRACT:
Traditionally elementary teachers have been generalists, responsible for teaching all subjects to their pupils. As part of science education reform movements, one suggested means of improving science instruction in elementary school classrooms has been the use of elementary science instructional specialists: teachers with particular interest or talent in science that take on multiple groups of students. Calls for research on the models of science specialization being employed and their relative effectiveness go back at least two decades, yet there are relatively few such studies in the literature. In this paper, we describe the models of elementary science specialization present in local school districts as well as the factors found to influence the creation, evolution, and persistence of these models. Our findings indicate that the predominant model of specialization is that of the single-grade level departmentalized or collaborative specialist. However, we also found one particular district that is wholly committed to having multiple-grade true science specialists with dedicated science classrooms. Factors influencing the presence and persistence of specialist models were varied and often school context-specific. Implications for research and use of specialist models in practice will be described.

Talk and Power: Changing our Dynamics
Elizabeth W. Edmondson, VIrginia Commonwealth University
ABSTRACT:
This paper investigates the discourse interactions that occur during a two week science camp embedded within a month-long professional development. Meaningful discourse in the classroom requires teachers to relinquish power to the students. Rheinvold and Cochran (2011) examined the power dynamics and questioning in one elementary classroom without discourse professional development. Analysis of 13 discourse sessions from transcripts involved close reading of the program transcripts and coding for IRE interactions first. Then, our analysis centered on power relations. We organized power themes into dialogic communication patterns, complexity of questions, and teacher control of utterances. Post camp perception questions related to classroom discourse, camp lesson plans, and camp observation notes were analyzed following a constant comparative process of grounded theory (Glaser, 1978). Students and teachers talked equally during these sessions. We found that 46 to 100% of the exchanges were between the teacher and one student, thus following a traditional IRE model. Teachers used a conventional type of power that kept them in control of the discussion. Our PD

model provides a great opportunity to learn and try, but teachers need additional time to practice and a better understanding of how their use of conventional power reduces student interactions.

Exploring Young Childrens' Views of Creativity in Science: Perspectives from an English Primary Classroom
Deb J. McGregor, Oxford Brookes University
ABSTRACT:
Creativity is important in the elementary classroom to nurture ingenuity and inventiveness in young children. This is essential because we do not know what kinds of skills they may need in life after school (who would have known six years ago school leavers needed to understand the impact and implications of social media, for example). With unknown challenges ahead, encouraging creativity in the classroom requires the student to be an active thinker, recognise opportunities to be imaginative and utilise ways of being creative when appropriate. Listening to children explain their view of creativity can inform teacher's pedagogical efforts to support it. This study based on a small sample of pupils (ages 5-7), in a school, rated as 'outstanding' by Ofsted, in Oxfordshire, explores childrens' views of creativity. It examines the opinions of these pupils and their perspectives of originality in and out of the science classroom. The findings suggested that young children can recognise and appreciate creative characteristics and how these might be utilised to further develop and augment their individual creativeness through generating original ideas and thinking independently.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Integrations and Innovations in Science Teaching
1:15pm - 2:45pm, Columbus IJ
Presider: Mehmet Aydeniz, The University of Tennessee

Implementing RRI Aspects in the Classroom
Yael Shwartz, The Weizmann Institute of Science
Emil Eidin, Weizmann Institute of Science
Maria Evagorou, University of Nicosia
Ameri Tenckhoff, Innovation in Learning Institute
Sonia Hertzner, Innovation in Learning Institute
Tony Sherborne, Sheffield Hallam University
Jorn Nyberg, Vestfold University College
Harald Bjar, Vestfold University College
ABSTRACT:
In this paper we present preliminary results of a pilot situated in the frame work of the European project named "Engage". The project's main goal is to interoduce, practice and disseminate RRI agenda (responsible research and inovation) in schools around Euorope. The project is planed to run for three years during them we intend 1) to produce RRI learning materials for classroom activities, including a localization phase for each country 2) to develop teachers' training (blended approach); 3) to use an open source platform, which also includes a wide library, and an integrated tracking system for monitoring and analyzing users' progress and behavior within the training. The learning materials are based on the concepts and experiences of the upd8 project in the UK, which have been produced and used in schools for more than 10 years. The materials were localized and adopted to the piloting countries. The evaluation took place in school classes in four different countries: Israel, Cyprus, Norway and United Kingdom. We got pretty good feedback from both students and teachers, who showed engagement and interest in the activities. In addition the teachers provided helpful insights and recommendations for future implementation.

SCM: Measuring Students' Interest Within and Beyond the Formal Science Classroom
Brady Michael Jack, National Sun Yat-sen University, Taiwan
Ling Lee, National Sun Yat-sen University, Taiwan
Kuay-keng Yang, National Sun Yat-sen University, Taiwan
Huann-shyang Lin, National Sun Yat-sen University, Taiwan
ABSTRACT:
This paper showcases the Science for citizenship model (SCM) as a new approach for measuring the extent to which Taiwanese high school students' (n=678) ignited and maintained interest during instruction in specific science content can persist beyond completion of that instruction. Results of using SCM on pretests, posttests, and delaytests data from students' participation in a short nanotechnology course revealed acceptable model fit to data and demonstrated students' interest in science can persist beyond completion of instruction if that instruction is contextualized to students' existing science knowledge and real-life experiences. SCM may enhance frontline science educators and investigators assessments of the impact of instruction on emerging technologies on students' interest in science.

Two Roles for the Crosscutting Concept in Supporting Students' Learning in a NGSS Focused Unit
Sarah J. Fick, Wake Forest University
ABSTRACT:
The Next Generation Science Standards focus on the integration of three dimensions of science education: disciplinary core ideas (DCIs), scientific practices (SPs), and crosscutting concepts (CCCs). Although the standards describe combinations of the three dimensions, how the CCC might be integrated into practice was unclear. Using a curricular unit co-developed with the teacher who enacted it, this study asks: What does integration of the three dimensions look like in middle school classrooms? This study uses qualitative analysis to identify instances of the CCC in: the written curricular unit, student interviews, pre- and post-tests, homework assignments, and video capturing full class and small group discussions. The CCC appeared in the analysis in two ways: the enacted curriculum included three lessons with integration of all three dimensions due to modifications by the classroom teacher or students; and, students included components of the CCC in their conceptual models. This research illustrates two roles the CCC can play: (a) as a tool for developing a deeper understanding of the content, and (b) as a resource for students' development of connections across science disciplines. This has implications for how classroom discussion and curricular materials can be used to support the development of three-dimensional science knowledge.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Culture of Science: Attitudes, Beliefs, and Understandings
1:15pm - 2:45pm, Roosevelt
Presider: David F. Treagust, Curtin University

Using Issue Analysis to Promote Climate Change Literacy: The Case of a Non-majors Science Course
Amy Trauth-Nare, University of Delaware
Steven Prentice, Towson University
Cynthia Ghent, Towson University
ABSTRACT:
The purpose of our study was to investigate the efficacy of using issue analysis to promote understanding of climate change concepts among undergraduates enrolled in a non-majors science course. Students participating in the study read and discussed three articles on climate change written from different viewpoints and then responded to a series of writing prompts. Students responses were evaluated based on four criteria, including their ability to: (1) discern difference between the greenhouse effect and climate change, (2) relate human

activities to climate change, (3) explain differential effects of climate change across the globe and (4) describe the benefits and drawbacks of mitigating climate change. Findings indicate that students made modest but significant gains in understanding of climate change concepts related to three of the four criteria, but did not increase their understanding of the differential effects of climate change across the globe. Implications of this study include the need to incorporate the sociopolitical and economic aspects of climate change into the curriculum and the necessity of reinforcing students' nascent understandings of concepts with multiple active learning opportunities that link the interconnected factors and systems involved in climate change.

Boosting Students' Attitudes and Knowledge About Evolution Sets Them Up for Success in College Biology

Benjamin E Carter, Syracuse University
Lynn M. Infanti, Christian Brothers Academy, Syracuse, NY
Jason R. Wiles, Syracuse University

ABSTRACT:
Students who enter college with a solid grounding in and positive attitudes toward evolutionary science are better prepared for and achieve at higher levels in university-level biology courses. We found highly significant, positive relationships between student knowledge of evolution and attitudes toward evolution as well as between introductory biology course achievement and both pre-course acceptance of evolution and pre-course knowledge of evolution among students at a medium-sized private northeastern university. Teachers who scant the teaching of evolution or who do not foster good attitudes toward evolution are compromising their students' potential for success in science at the college level.

Student Epistemologies in Majors' and Non-Majors' Biology Courses

Katherine N. Mollohan, The Ohio State University
Lin Ding, The Ohio State University

ABSTRACT:
This study reports survey research with undergraduates in respect to their epistemologies about biology and learning biology. We investigated epistemic differences between science and non-science majors, and students' changes in attitudes and beliefs over the course of a semester of instruction. We used the Colorado Learning Attitudes about Science Survey for Biology (CLASS-Bio) with participants (n=171) from both science major and non-science major biology courses. Results indicated that before instruction, students in the science major course had a significantly higher percentage of favorable responses (responses aligning with experts' views) than those in the non-science major course. However, post-instruction results showed a different pattern, with the non-majors outperforming the majors. Using matched comparisons, we discovered that the science majors exhibited novice-like shifts in their epistemologies over the course of a semester, whereas non-science majors overall showed positive gains in their epistemologies.

Examining College Students' Beliefs about NOS, Scientific Reasoning, Religiosity, and Understanding and Acceptance of Evolution

Ann M.L. Cavallo, The University of Texas at Arlington
Stephanie Gutierrez, The University of Texas at Arlington

ABSTRACT:
Understanding evolution provides students with an underlying framework in biology that is essential to learning more complex, interrelated scientific concepts; yet most educators find public understanding of evolution to be significantly deficient. The purposes of this study were to examine patterns and differences, explore interrelationships, and determine the best predictive model among students' views about the nature of science (NOS), scientific reasoning, religiosity, and understanding of evolution on their acceptance of evolution. Questionnaires measuring college students' understanding of evolution, views of the nature of science, religiosity, understanding of evolution, and acceptance of evolution were given to 121 students of diverse

backgrounds. The results of this study indicated gender differences favoring males in scientific reasoning ability, differences in students' views about the nature of science and religiosity based on ethnicity, and significant correlations between reasoning ability, understanding of evolution, views of the nature of science, and acceptance of evolution. Students' views of the nature of science, religiosity, and understanding of evolution were significant predictors of their acceptance of evolution. The results contribute to increased understanding of how these factors may hinder or promote students' acceptance of evolution and may help educators design better instruction to support learning evolutionary theory.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Instructional Practices - Collaboration and Development
1:15pm - 2:45pm, Comiskey
Presider: Shiyu Liu, Pennsylvania State University

Constructing 'Authentic' Science: Results from a University-High School Collaboration Integrating Digital Storytelling and Social Networking
Stacy Olitsky, Saint Joseph's University
Elizabeth A. Becker, Saint Joseph's University
Joe Montcalmo, Saint Joseph's University
Ignacio Jayo ,Tennent High School
Phillip Vinogradov, Tennent High SchoolSchool
ABSTRACT:
This study explores the results of implementing innovative practices within a college neurobiology classroom that entails student-directed research on the behavioral deficits of brain lesions. The professor collaborated with a high school science teacher and academic technology staff to revise her class to integrate the following components: student documentation of research projects through using IPads, digital storytelling, and on-going communication with a class of high school students. The college and high school students interacted through an education social networking site and on-campus visits where high school students observed rat brain surgery and behavioral testing. The aims of the course redesign were to 1) make the science that they were taught more closely aligned with the science conducted in the field, and 2) give students an understanding of the importance of disseminating science through emerging technologies. This study investigates the impact of these innovations on the faculty member's, college students', and high school students' perceptions of "authentic science", science-related communities, and their own relationships to science. We address the question: In what ways does an approach that integrates digital storytelling, social networking, and high school-college collaboration change how "authentic" science is experienced and enacted by participants?

Engaging in Self-Study to Support Collaboration between Two-Year Colleges and Universities
Andrea Gay Van Duzor, Chicago State University
Geraldine L. Cochran, Rochester Institute of Technology
Mel S. Sabella, Chicago State University
ABSTRACT:
Collaboration between two-year colleges (TYC) and four-year universities (FYU) can facilitate incorporation of research-based science curricula and programs. Physics faculty at three TYC and a public, comprehensive FYU in a large mid-western metropolitan city have been collaborating for over five years on projects focused on two goals: improving physics instruction and promoting high school science teaching careers. The collaboration began with the implementation and refinement of novel instructional tools for use with diverse student populations and now includes a Learning Assistant program. To improve the collaboration and to illuminate successful elements of TYC/FYU partnerships, the collaborative engaged in a qualitative case self-study using a

lens of structure and agency. Data analysis revealed tensions, which could serve as affordances or constraints, including whether the partners are individuals or institutions, if the partners are consumers or producers within the partnership, balancing flexibility and formality in instituting programs, and whether the focus of the partnership is specific products or the process of collaboration. The study has implications for methods of initiation and continued development of TYC/FYU partnerships that emphasize inquiry based science instruction.

A Motivational Approach to Examining Reasons Why STEM Faculty Engage in Teaching Professional Development

Jennifer Collins, Oregon State University
Jana L. Bouwma-Gearhart, Oregon State University

ABSTRACT:
This paper reports on a quantitative study that examined the teaching competency and motivations to engage in teaching professional development of 227 STEM faculty at research universities. Our findings reveal that faculty feel competent with respect to their teaching and engage in teaching professional development more for autonomous reasons compared to controlled reasons.

The Impact of Group Work on Junior Secondary Science Learning

Dennis Fung, The University of Hong Kong

ABSTRACT:
Building upon Piaget's (1932) theory of constructivism with regard to children's cognitive development, a proposed intervention was taken in the form of a series of 16 lessons in the junior secondary integrated science curriculum. It was enable teachers to play a crucial role in encouraging their students to evaluate alternative conceptions and common-sense beliefs about science. The intervention placed emphasis both on enhancing student engagement and the importance of teacher guidance. Methodologically, the study was guided by a conceptual framework that is underpinned by the work of Vygotsky (1978) and divided into three inter-related domains: 'whole-class teaching', 'self-directed student group work' and 'teacher-supported group work'. Informed by a quasi-experimental research design, the study adopted a mixed-methods approach to examine the relationship between different types of pedagogy and students' academic and attitudinal changes in science learning. Samples of students' written responses, showing how they worked collaboratively to draw inferences or produced alternative arguments in science discourse, were collected through tasks involving predictions of experimental outcomes. The results indicated that group work is productive and teacher's role is beneficial for students' learning in science. The findings have potential implications for other contexts in which social interaction supports cognitive development in science.

Strand 6: Science Learning in Informal Contexts
Informal Science Learning Out of Doors
1:15pm - 2:45pm, Water Tower
Presider: Deborah L. Bailey, OregonOregon State University

Community-Based STEM: An Environmental Science Education Partnership in a Large Midwestern City

Dean J Grosshandler, University of Illinois at Chicago
Alejandro Grajal, Chicago Zoological Society
Jo-Elle Mogerman, Chicago Zoological Society
Michael Howard, Illinois Dept. of Natural Resources and Eden Place Nature Center
Lisa-Anne DeGregoria Kelly, Chicago Zoological Society
David P. Becker, Chicago Zoological Society

ABSTRACT:
Through a collaboration between a community-based organization and nature center located in a severely under-resourced Midwestern urban neighborhood, a leading informal science learning and research institution in a major metropolitan area, and a large metropolitan university, the Midwestern Community STEM Collaboration is joining forces to create a "STEM education ecosystem" in a severely under-resourced urban community. The project weaves education programs into an ecosystemic learning model, including providing the community with thematically aligned environmental science learning resources for a variety of ages and audiences. This model also includes professional development for teachers in inquiry, conservation, and early childhood education professional development; classes for K-12 students in environmental conservation; and programs for pre-K to Gray public audiences including families, adults, teens, and children, creating a new approach to community development through environmental awareness, action, and agency. This 4-year project is funded by the National Science Foundation Advancing Informal STEM Learning program, and includes research and evaluation components in addition to program implementation.

Dividing Attention Participation to Support Informal Learning

Aubin StClair, University of Southern Mississippi
Kristy L. Halverson, University of Southern Mississippi
Aimee K. Thomas, Loyola University New Orleans
Carrie J. Boyce, The University ofof Southern Mississippi

ABSTRACT:
There is a constant push to increase students' learning and interest in STEM, particularly environmental science. However, middle school students tend not to spend ample time outdoors, opting instead to focus on screens (TVs, computers, etc.) indoors. Informal science programs have tried to counter this nature deficit. In our study, we have integrated the use of mobile technology during a naturalist led nature hike to try to increase student motivation to explore the environment. Specifically, the purpose of our study is to explore the relationships among the social, technology, and nature participation. We used a modified Attention Participation model (Rochelle, 2003) to frame our qualitative study of 24 middle school participants. We found that the attention participation planes both facilitate learning and hindered different aspects of learning on the hike pending the complementary nature of the interactions. For example, we found that iPads motivated students' interest in hike participation and aided in event recollection. Likewise, by having students share iPads the technology plane facilitated learning through social interactions, a critical aspect in maintaining interest STEM. Pursuits of research on how attention planes contribute to learning environments will better help us understand how learners divide participation to maximize learning gains.

The Effect of Youth Gardening on Perceptions of Science

Deborah L. Bailey, Oregon State University
John H. Falk, Oregon State University

ABSTRACT:
Many view garden-based learning as the panacea to numerous science-related literacy issues, for example agricultural literacy, environmental literacy, and general STEM literacy, not to mention societal issues such as adolescent delinquency, and childhood overweight and obesity. However, much of the domain specific literature in the area of garden-based learning focuses on internal cognitive constructs such as science knowledge, motivation, interest in and attitude and little work has been done to explore the affect of a garden experience on youth's perceptions of science. This case study explored the adolescent learner's perspective of a summer garden experience in an attempt to explore the affect of youth gardening on perceptions of science. It utilized an informed grounded theory approach and personal meaning mapping (PPM). Research questions focused on youth's perceptions of their garden experience and how they connect these perceptions to their understanding of and experiences with science.

"How Much Nature" Is There in Field Trips in Natural Environment?

Nirit Lavie Alon, Technion
Tali Tal, Technion

ABSTRACT:
In this study, we aimed at understanding how guides refer to, and use, the natural environment while guiding field trips and how its use contributes to the learning outcomes. We studied 43 field trips to natural environments with respect to the content and skills the guides taught and their teaching methods. Data included observations and interviews with 33 teachers, 26 guides and 128 students and an open-ended question. We found that the guides often refer to phenomena and concepts that can be seen in the surroundings, but they rarely discuss the conflict between humans and the environment, and teach almost no outdoor skills. The guides often explain, ask and answer questions, but hardly address their own occasional discoveries or objects that students find. They almost never encourage exploration of the environment, seldom allow free time to experience nature, and rarely, if ever, incorporate pro-environmental action. Interviews with students indicated excitement and meaningful experiences related to the physical environment. Environmental action, reference to random findings in nature and the empowerment of nature stood out particularly as meaningful experiences and factors that contributed to shaping students' attitudes and environmental behavior intentions.

Strand 7: Pre-service Science Teacher Education
Teachers' Practices, Self-Regulation, and Assessment
1:15pm - 2:45pm, Grand Suite 5
Presider: David F. Jackson, The University of Georgia

Science Methods Course Influences on Early Childhood Preservice Teachers' Evolving Self-Efficacy about Equitable Science Teaching

Eun Young Lee, University of North Texas
Karthigeyan Subramaniam, University of North Texas
Pamela Harrell, University of North Texas

ABSTRACT:
This study investigated the effect of a science methods course on the self-efficacy beliefs of early childhood preservice teachers in regards to equitable science teaching and learning. Using the Self-Efficacy Beliefs about Equitable Science Teaching (SEBEST) instrument (Ritter, Boone, & Rubba, 2001) pre-and posttest data from 67 preservice teachers who were enrolled in four different sections of science methods courses were analyzed. Results from this study suggest that after taking a science methods course, there was a statistically significant change in early childhood preservice teachers' Personal Science Teaching Efficacy (PSTE) toward equitable science teaching and learning for diverse learners.

The Role of Pre-Service Science Teachers' Achievement Goal Orientation and Gender in Prediction of Self-Regulation

Solmaz Aydin, Kafkas University
Sündüs Yerdelen, Kafkas University

ABSTRACT:
The purpose of this study is to investigate the predictive power of pre-service science teachers' achievement goal orientation and gender on their self-regulation. Sample of the study consisted of 214 pre-service science teachers (123 female, 91 male) at Kafkas University in Turkey. In the present study, survey method was used to collect data and students were administered Achievement Goal Orientations Scale (AGOS) and self-regulation Questionnaire (SRLQ). Multiple linear regression analyses were used to analyze the data. While self-regulation

was attained as dependent variable, mastery goal orientation, performance approach goals, performance avoidance goals, and gender were used as predictors. Results showed that among these variables, mastery goals (β=.265) and Performance avoidance goals (β=-.194) were found to be significant predictors of self-regulation.

Using Case Method to Explicitly Teach Formative Assessment in Preservice Teacher Education

Amy E. Bentz, Western Michigan University
William W. Cobern, Western Michigan University

ABSTRACT:
The process of formative assessment improves student understanding; however, the topic of formative assessment in preservice education has been neglected. Case method is an instructional methodology that can enhance preservice teachers' awareness of formative assessment. Research on using case method to explore the formative assessment process is sparse. The purpose of this study is to answer the following research questions: To what extent does the implementation of formative assessment cases influence preservice elementary science teachers' knowledge of formative assessment? What descriptive characteristics change between the preservice teachers' pre-case and post-case reflections that would demonstrate learning occurred? Results indicate that the preservice teachers modified their ideas to reflect the themes that were represented within the cases and modified their reflections to include specific ideas or examples taken directly from the case discussions. The data supports a noted change in how the preservice teachers: evaluated the case content, questioned the lack of formative assessment concepts/strategies within the case, and applied formative assessment concepts/strategies within their own case descriptions. The results of this study further strengthen the existing literature on formative assessment instruction in preservice teacher education, and support the call for further attention given to utilizing case methodology.

Supporting Secondary Science Pre-Service Teachers in Developing Ambitious Lesson Planning Practices

Danielle K. Ross, Northern Arizona University

ABSTRACT:
This study followed pre-service secondary science teachers as they participated in a secondary science teacher preparation program intended to support the development of their lesson planning and supporting of whole-class task-based discussions. Teacher educators in this program designed an intervention that aimed in supporting this development. By documenting how/whether PSTs engaged in the following instructional planning practices: developing Learning Goals, selecting and/or designing challenging tasks, anticipating student thinking, planning for monitoring student thinking, imagining the discussion storyline, planning questions, and planning marking strategies, analyses showed a significant difference between baseline lesson plan scores and Instructional Performance scores. These findings suggest these patterns and changes were directly linked to the teacher preparation program. The mean increase in Instructional Performance scores during the course of the teacher preparation year further supports the effect of the teacher preparation coursework.

Strand 8: In-service Science Teacher Education
Supporting Teachers for STEM Implementation
1:15pm - 2:45pm, Columbus KL
Presider: Meredith A. Park Rogers, Indiana University

Supporting Middle School Teachers' Implementation of STEM Design Challenges

Tamara Holmlund Nelson, Washington State University Vancouver
Kristin Lesseig, Washington State University Vancouver
David Slavit, Washington State University Vancouver
Cathleen Kennedy, Education Research Consultant, KAC Group

Ryan Seidel, Washington State University Vancouver

ABSTRACT:
We describe a three-year PD model designed to deepen middle school teachers’ content knowledge and PCK in relation to ratio and proportion and the science content specific to their kit-based science materials, and to increase their capacity to integrate STEM practices across STEM disciplines. A unique aspect of this model involves “less successful” students and their teachers learning alongside each other as they co-participated in STEM design challenges for one week in the summer. Findings reported here are based on data from the inception of the PD project in the summer of 2013 through the 2014 summer institute, including teachers’ implementation of design challenges during the 2013-14 school year. Our analysis focuses on what teachers reported they learned and the challenges they encountered when implementing interdisciplinary STEM challenges with diverse students. The two most significant areas of learning and challenge were: 1) the complexities teachers encountered in ensuring rich STEM content and opportunities for students to explicitly employ STEM practices when engaged in a design challenge, and 2) teachers’ recognition, as a result of working side-by-side with selected students in the summer, that all students (including special education and English language learners) could successfully accomplish the design challenge.

Challenges and Successes: Understanding Middle School Physical Science Teachers' Experiences with STEM Integration

Gillian Roehrig, University of Minnesota
Emily A. Dare, University of Minnesota
Joshua A. Ellis, University of Minnesota
Tamara J. Moore, Purdue University
Selcen Guzey, Purdue University

ABSTRACT:
Recent national documents call for improvements in K-12 STEM education to increase STEM literacy and motivate students to pursue STEM fields (National Research Council, 2011). Despite this push, though, the STEM fields are currently taught as isolated disciplines and there is a general lack of opportunities for teachers to participate in integrated STEM-related professional development (National Academy of Engineering, 2009). Our project is an NSF Mathematics and Science Partnership involving partners from higher education and K–12 schools designed to promote K–12 STEM integration. The overarching goal of our work is to increase student learning of science and mathematics by using an engineering design-based approach for integrated STEM instruction to guide professional development and curricular design for science teachers. This work focuses on six of the 48 teachers involved in the 2013–2014 year of our project, focusing on those who taught physical science content. Through analyzing data from both observer and participant perspectives, this work aims to better understand the successes and challenges that science teachers face as they work to bring integrated STEM to their classrooms.

Professional Development through STEM Integration: How Early Career Math and Science Teachers Respond to ExperiencingExperiencing Integrated STEM Tasks

Christopher A. Bogiages, Knowles Science Teaching
Christopher A. Bogiages, Knowles Science Teaching Foundation
Rachael Brown, Penn State Abington
Joyce Lin, Knowles Science Teaching Foundation

ABSTRACT:
In our work providing professional development to early career math and science teachers, we have found it useful to engage teachers from various disciplinary backgrounds in integrated STEM tasks to promote teacher learning. In this study, we define STEM integration as an instructional approach in which learning goals from two or more STEM disciplines are achieved through the integration of disciplinary practices such as scientific

inquiry, mathematical analysis, or technological design as described by national standards documents (NGSS,2012, CCSS, 2010). The research described in this paper was aimed at the development of a deeper understanding of the affordances and challenges of using integrated STEM tasks in the professional development of in-service secondary science and math teachers. Our findings from this qualitative study of early career math and science teachers, include detailed descriptions of how teachers engage with integrated STEM tasks and what elements of the task foster different types of engagement. The implications of these findings will be discussed with respect to in-service teacher professional development providers, researchers interested in integration of STEM disciplines, and classroom teachers of secondary level math and science.

Instructional Coaching Support to Science Teachers for the Implementation of STEM Integrated Curriculum

Tasneem Anwar, University of Minnesota
Gillian Roehrig, University of Minnesota

ABSTRACT:
During the recent years STEM integration has been 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 "Big four"; behavior, content knowledge, direct instruction, and formative assessment (Knight, 2009) makes it a best fit to support science teachers for implementation of STEM integrated curriculum. This study focuses on the instructional coaching support provided to 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
Curriculum and Assessment
1:15pm - 2:45pm, Grand Suite 3
Presider: Eilish McLoughlin, Dublin City University

The Impact of Prior Knowledge and Self-efficacy on Students' Performance in the Virtual Environment

Xiaoyang Gong, University of Maryland
Bradley W. Bergey, Dalhousie University
Diane Jass Ketelhut, University of Maryland
Kelly Mills, University of Maryland
Ashley N. Coon, University of Maryland

ABSTRACT:
This study investigated how prior conceptual knowledge and self-efficacy beliefs influenced students' performance in an inquiry-based assessment module delivered by the virtual environment. The crosstab, one-way ANOVA and Post-hoc Student-Newman-Keuls test were used to examine the relationship. The study found that some students who had limited conceptual knowledge were still able to perform well in the module. The further analysis showed that these students had significantly higher pre-module self-efficacy compared to those who did not perform well in the module. These results suggest that scientific inquiry self-efficacy may be driving behavior in the module that leads to learning that results in higher module scores. Key words: virtual environment, self-efficacy, prior conceptual knowledge, scientific inquiry

Using Model-Based Reasoning to Achieve Curricular Coherence in High School Biology

Candice Guy, University of California, Davis
Julia Svoboda Gouvea, Tufts University
Cynthia Passmore, University of California-Davis

ABSTRACT:

Coherence is an important element of curriculum design; however, there is work to be done in developing curriculum coherence theory within the context of the Next Generation Science Standards. In this paper, we explore a novel strategy for using model-based reasoning to achieve three facets of curricular coherence: conceptual, epistemological, and practice-oriented. We present a theoretical argument for how model-based curricula can support these multiple coherences and illustrate how we have used this theory to inform our design of a yearlong high school biology curriculum. We present and discuss two structural features of our curriculum: model triads and model-based curricular looping. Model triads, link together phenomenon, question, and model, and form the basic unit of the curriculum at a small grain size. Model-based loops draw on the interrelatedness of families of models to connect units of study together at a larger grain size. The looping structure follows chains of mechanistic questioning to promote a line of inquiry within a series of interrelated models. Concepts within this line of inquiry may be "black-boxed" and unpacked later, or unpacked during the initial pass. We use the curricular structure to illustrate the strategies we have used to achieve coherence through model-based reasoning.

Singaporean Secondary Science Teachers' Conceptions of Assessment

Gavin W. Fulmer, National Institute of Education (Singapore)
Kelvin H. K. Tan, National Institute of Education (Singapore)
Iris C. H. Lee, Singapore Ministry of Education

ABSTRACT:

This study reports on findings of a randomized, nationally representative survey of Singaporean secondary teachers about their conceptions of assessment (COAs) and the contextual factors that influence their views, knowledge, and practices of assessment -- here focusing only on the science teacher participants. Findings indicate that the science teachers endorse the notion that assessment serves purposes of school accountability, student accountability, and improvement. However, unlike prior study in Western settings, the teachers do not endorse the view that assessment is irrelevant. Additionally, positive correlations between school accountability and both student accountability and improvement indicate that, for our teachers, there is not a discrepancy between accountability and improvement at the school level and at the school level. Our findings for contextual factors that influence the teachers reveal that teachers feel they are knowledgeable and capable to implement assessments, but they endorse the view that more assessment-specific education is needed for pre-service and in-service teachers. They also desire more recognition and support from policymakers for their efforts to implement innovative assessment approaches.

Incorporating Practice into Content: The Field Testing of the Scientific Decision-making Unit

Nancy Moreno, Baylor College of Medicine
Alana Newell, Baylor College of Medicine
Ron McNeel, Baylor College of Medicine

ABSTRACT:

Science education materials aligned with the Next Generation Science Standards must provide students with learning opportunities that reflect the real-world practice of science as well as prepare them to be scientifically literate citizens. The Scientific Decision-making curricular materials combine these two goals by providing students with content knowledge about the cardiovascular system and the health risk factors of ischemic heart disease through the investigation of simulated cases. Through the case studies, students follow the same paths medical personnel would take in the healthcare decision-making process. This topic is particularly important as misinformation about heart disease and low health literacy can be barriers to informed health decision-making especially in underserved, low-SES, and non-English speaking communities. Outcomes from three assessments administered during the field testing of these materials indicate that the diverse group of students using the materials grasped both content knowledge and the decision-making process, and were able to retain the information once the unit was completed.

Science education from a European perspective: Results from the International PROFILES Curricular Delphi Study

Claus Bolte, Freie Universtaet Berlin
Marlies Gauckler, Freie Universitaet Berlin

ABSTRACT:
In the context of the European PROFILES project, the "International PROFILES Delphi Study on Science Education" was conducted in 19 European countries, collecting data from more than 2.700 people involved in science education or science. The data was gathered and analysed by each country separately to give insights into their national science education. However, in this contribution, the data of the national Delphi curricular studies is compiled and compared. Therefore, we can present aspects of science education which are perceived as especially relevant by a collective of European stakeholders. In addition, we will show which aspects are realized to a higher and lower extent in science education. The comparison of the importance and extent of practice attributed to each aspect allows the identification of areas which require further improvement in European science education.

Strand 10: Curriculum, Evaluation, and Assessment
Physics and Chemistry Education
1:15pm - 2:45pm, Columbus GH
Presider: Cari F. Herrmann Abell, AAAS/Project 2061

Data-Driven Inquiry: High School Chemistry Teachers' Use of Classroom Assessments

Jordan Harshman, Miami University
Ellen J. Yezierski, Miami University

ABSTRACT:
Data-driven inquiry (DDI) is the process by which teachers design and implement classroom assessments and use the results to adjust teaching. Very little is known about how teachers implement this process daily in science, let alone chemistry specifically. Nineteen high school chemistry teachers participated in a semi-structured interview regarding how they used assessment results in recent assessments to inform their teaching. Research results are reported for each of four steps in the DDI process. Goals – There was a general lack in specificity of learning and instructional goals and those instructional goals stated were not conducive to informing instruction. Evidence – At least once, all teachers who collected assessments from their students determined student learning based solely on scores, suggesting an over-reliance on these measures. Conclusions – Many teachers claimed that students either did or did not "understand" a topic without adequately describing what this means. Actions – Very few teachers stated a specific action as a result of analyzing student data, while the majority of teachers gave multiple broad pedagogical strategies to address content deficiencies. The results of this study show the limitations of teachers' DDI practices and inform how professional development on DDI should have a finer grain size and be based in disciplinary content.

Validating a Learning Progression for the Energy Concept: An Interview Study-based Method

Susanne Wessnigk, Leibniz Institute for Science Education (IPN) Kiel

Knut Neumann, Leibniz Institute for Science Education (IPN) Kiel

ABSTRACT:
Research has provided ample evidence that students understanding of energy progress along a sequence of four key ideas: forms/sources; transfer/transformation, degradation; conservation. These findings were corroborated in a recent large-scale study with middle school students in a large German metropolitan area. This present study aims to provide further evidence for the validity of previous results about the development of an energy understanding exemplified in this recent German study. Therefore 41 participants of grade 7, 9 and 11 were interviewed using a semi-structured interview protocol and completed a paper-pencil test. In the interview students were provided with special scenarios (e.g. trampoline) and were asked about the four key ideas of energy. In addition, students received energy-form cards for support and were asked to use those when describing the scenarios. Our results support the findings of previous studies about the development of an energy understanding and provide further evidence for its validity. Moreover, our results indicate that our interview technique provides valid and reliable data and we acquired a deeper insight into students thinking about energy.

Measuring Knowledge of Acids and Bases as Continuous and Categorical Constructs toward Understanding Concept Progression

Amber Todd, Wright State University
William L. Romine, Wright State University

ABSTRACT:
We describe the development and validation of the Measure for Conceptualization of Acids and Bases (MCAB) for college students. Items were constructed based on a learning progression framework of acids and bases (Lin and Chiu, 2007). After thorough content review, continuous and categorical scales were constructed using Rasch and Latent Class Mixture Model frameworks, respectively. A valid and reliable 28-item instrument was the outcome of two rounds of data collection and revision. The Rasch scale was shown to be reliable and unidimensional, and the items fit well with the Rasch model. Latent Class Analysis (LCA) showed that the data were described adequately by a 2-class scale. Students in Latent Class 1 demonstrated conceptions of acids and bases consistent with the phenomenon and character-symbol models (Lin & Chiu, 2007). With some exceptions, the students in Latent Class 2 demonstrated conceptions consistent with the scientific model (Lin & Chiu, 2007). Rasch score predicted Latent Class with 93% accuracy, demonstrating that classes derived from LCA are a “progression” in the sense that we use the word. Use of Rasch and LCA models toward generalized understanding of how college students conceptualize acids and bases is discussed.

Assessment Policy in the Current Senior Physics Curriculum Documents of Mainland China and Hong Kong

May Hung May Cheng, The Hong Kong Institute of Education
Zhi Hong Wan, The Hong Kong Institute of Education

ABSTRACT:
Mainland China and Hong Kong published their new senior science education curriculum documents in 2003 and 2007 respectively, in which both areas include assessment innovation as an important part of their curriculum reforms. A comparison revealing the function of assessment; interpretation of summative and formative assessment and the bridging of summative and formative assessment, is made between assessment policies as illustrated in the two current physics curriculum documents from Mainland China and Hong Kong. Some similarities are identified, such as promoting the role of assessment for improving teaching and learning physics, advocating the integration of formative assessment and summative assessment, and types of assessment activities. Differences are observed in four aspects: (i) argument of the function of assessments in selecting students; (ii) interpretation of the concepts of and the relations between formative and summative assessment; (iii) description of internal and public assessment, and (iv) the strategy of bridging formative and summative assessment. This paper discusses the factors within and beyond education that may contribute to the shaping of

such differences. Implications on the introduction of assessment innovations in other countries or regions are drawn.

The Force Concept Inventory–Impact of Context and Response Format

Hendrik Haertig, IPN - Leibniz-Institut Naturwissenschaften U. Mathematik

ABSTRACT:

The Force Concept Inventory [FCI] aims to capture the understanding of the force concept with multiple-choice [MC] items. The validity of the FCI has been discussed. Based on former research we examined, to what extent the response format as well as the context of an item affect the results within one subscale of the FCI. Our test contains 26 items, 13 as open response format, and the same 13 as MC items. 7 of the 13 items are original FCI questions with similar content (type of force: gravitation) and two groups of additional items with the same content and different context (e.g. golf and soccer) have been constructed based on two original FCI items. Each of 610 students received each of the 26 items. Using structural equation modeling we are able to show, that the response format indeed has an impact on the results. Furthermore we found an effect of the context of a specific item as students' answers are inconsistent throughout different contexts in open-ended questions. The study shows that even new approaches analyzing the FCI based on learning progressions might be limited. We would encourage the community putting more emphasis on open ended responses in concept inventories.

Strand 12: Educational Technology

Digital Gaming in Science Education

1:15pm - 2:45pm, Grand D North

Presider: Richard L. Lamb, WashingtonWashington State University

Examination of Latent Class Profile Transition Analysis of K-12 students STEM Career Selection Moderated via Serious Educational Games

Richard L. Lamb, Washington State University
David B. Vallett, University of Nevada Las Vegas
Len Annetta, George Mason University
Kaylan Petrie, Washington State University
Rebecca Cheng, George Mason University
Marina Shapiro, George Mason University
Ben Matthews, George Mason University

ABSTRACT:

Attention on P-12 STEM education has increased in recent years. Many efforts are underway to promote STEM career selection across the nation. In the push to develop these programs and pathways to STEM career selection, educational researchers may overlook student characteristics contributing to career selection as they develop curriculum and work with preservice teachers. The purpose of this presentation is to examine underlying profile combinations of latent traits that mediate student STEM career selection through Serious Educational Games. The research question addressed in this study is; what student profile is most likely to select STEM careers when engaged in science learning using a Serious Educational Game (SEG). The methods used within this study combine a number of quantitative analyses including Latent Class Profile Analysis. The purpose in the use of these methods is to develop a profile of students in a high school science classroom using a virtual learning environment and examine the effects of this profile on student career selection as evidenced by Holland Scores. Chi-square for the models are statistically significant, thus indicating that MENTAL ROTATION, ATTITUDE, and 21st CENTURY SKILLS do predict STEM career selection when moderated using a SEG learning environment.

The Influence of Serious Educational Game Design on Student Interest in STEM

David B. Vallett, University of Nevada Las Vegas
Richard L. Lamb, Washington State University
Len Annetta, George Mason University
Rebecca Cheng, George Mason University
Marina Shapiro, George Mason University
Ben Matthews, George Mason University

ABSTRACT:
This study examined the potential association between participation in the design process for Serious Educational Games and changes in learner affect and cognition within the treatment group, following a larger study comparing between groups. Linear regression methods indicated that learners who took a more active role in the design process as measured by investigators showed greater gains in their interest in learning science and their understanding of the content embedded in the SEG. While not the only factor in play, this study establishes that use of design processes may be important to fostering learner interest in STEM fields, teaching the cross cutting concepts in NGSS, and in further expanding learner understanding of content.

Immersive Multi-user Virtual Environments Support Development of Modeling Practices in Ecosystem Science

Amy M. Kamarainen, Harvard University
Shari Jackson Metcalf, Harvard University
Tina Grotzer, Harvard University
Chris Dede, Harvard University

ABSTRACT:
Recent reform efforts and the next generation science standards emphasize the importance of incorporating authentic scientific practices into science instruction. Modeling can be a particularly challenging practice to address because modeling occurs within a socially structured system of representation that is specific to a domain. Further, in the process of modeling, experts interact deeply with domain-specific content knowledge and integrate modeling with other scientific practices in service of a larger investigation. It can be difficult to create learning experiences enabling students to engage in modeling practices that both honor the position of the novice along a spectrum towards more expert understanding and align well with the practices and reasoning used by experts in the domain. In this paper we outline the challenges in teaching modeling practices specific to the domain of ecosystem science, and we present a description of a curriculum built around an immersive virtual environment that offers unique affordances for supporting student engagement in modeling practices. Illustrative examples derived from pilot studies suggest that the tools and context provided within the immersive virtual environment helped support student engagement in modeling practices that are epistemologically grounded in the field of ecosystem science.

The Earthquake Engineering Game: Synthesizing Instruction and Game Design for 21st Century Science Learning

Abigail C. Perkins, Texas A&M University
Carol L. Stuessy, Texas A&M University

ABSTRACT:
This study chronicles the research and development (R&D) of a collaborative educational game about engineering, in which players build an inhabitable and earthquake-resilient city. Learning objectives are to enhance critical thinking, scientific argumentation, and metacognition while highlighting the interconnectivity of urban infrastructure associated with disaster relief. Situated within a socio-cognitive framework, Earthquake fosters social learning and elucidates the STEM of everyday life. Few games have undergone an R&D process synthesizing instructional theory and game design. In response, this study covers the five phases of an R&D process: analyze, develop, design, implement, and evaluate. Focus groups drafted an educational and engaging

product to hook students, allow them to become immersed in the game, and to learn-by-doing. After beta-testing the game with STEM teachers, groups participated in open-ended interviews to capture playing experiences. Analyzed by constant comparison methods, transcribed interviews were organized into categories most appropriately serving game modification. A new game version was created based on resulting improvements, which high school students then played. Analysis from video-recorded game play using a specifically designed rubric indicates students improved in higher-order thinking and gained engineering knowledge. This research provides stakeholders empirical evidence of educational gaming benefits.

Strand 13: History, Philosophy, and Sociology of Science
Symposium - The Past, Present and Possible Future of HPS-informed Science Education Research
1:15pm - 2:45pm, Grand B
Presider: Michael R. Matthews, University of New South Wales
Presenters:
Jonathan F. Osborne, School of Education, Stanford University
Norman G. Lederman, Illinois Institute of Technology
Fouad Abd-El-Khalick, University of Illinois at Urbana-Champaign
Michael P. Clough, Iowa State University
Kostas Kampourakis, University of Geneva
Mike U. Smith, Mercer University School Of Medicine
Gregory J. Kelly, Penn State University
Sherry A. Southerland, Florida State University
Erin E. Peters-Burton, George Mason University
Wendy Sherman-Heckler, Otterbein College
ABSTRACT: Since the late nineteenth century there has been a continuous tradition of science education research that has been informed by the history and philosophy of science (HPS). Some of this research is normative (or advocacy), some is empirical, while most is inevitably a mixture of both. This HPS-informed research tradition covers three fields: (1) Theoretical questions such as: the status of traditional Enlightenment justifications, constructivist claims about the knowledge claims of science, feminist critiques of science, the status of indigenous or local sciences and how they should or should not be taught in science programmes, science and religion, the status of models in science, the function of internal and external values in science and their relation to cultural values, what is the nature of science and how is it best taught, etc. (2) Curriculum questions about the structure, content and scheduling of school science programmes; the justification of Disciplinary, STS and SSI curricula. (3) Pedagogical questions about how the utilisation of HPS can frame Inquiry teaching; can influence student motivation, interest and learning of science and about science. Ten contributors will appraise this tradition as it is connected to the recent book Science Teaching: The Contribution of HPS (Matthews 2015).

Strand 15: Policy
Related Paper Set - From Policy to the Classroom: Studying the Enactment of the NGSS Vision
1:15pm - 2:45pm, Gold Coast
Presider: Mary Kay Stein, University of Pittsburgh
Discussant: Christian Schunn, University of Pittsburgh
ABSTRACT:
The Framework for K-12 Science Education (National Research Council, 2012) together with the Next Generation Science Standards (NGSS; NGSS Lead States, 2013) has established a new vision for science teaching and learning. The related set of papers in this session bring together threads of research that aim to

examine and explain what happens when policymakers, leaders, and teachers attempt to make the NGSS come alive for students in science classrooms. The studies examine both the systemic features that shape classroom instruction and the instructional practice itself. How do teachers interpret the NGSS? What system-wide features support or hinder teachers' implementation of scientific practices with their students? What happens at the instructional level during the implementation of curriculum materials aligned with the NGSS vision? The four related papers in this session address these issues and provide implications for both researchers (how to study NGSS implementation) and practitioners (how to make the NGSS vision become real in science classrooms).

Examining Developing Teaching Practices at the Intersection of Content and Practice in Middle School Science
Britte H. Cheng, SRI International
Savitha Moorthy, SRI International
Cynthia M. D'Angelo, SRI International
Reina Fujii, SRI International
Tiffany Leones, SRI International
Bowyee Gong, SRI International
Jeremy Fritts, SRI International
Carrie D. Allen, University of Colorado - Boulder
Carrie-Anne Sherwood, University of Michigan
Christopher J. Harris, SRI International

Quality of Science Instruction during the Enactment of NGSS-Aligned, Cognitively Demanding Science Tasks
Miray Tekkumru Kisa, University of Pittsburgh
Mary Kay Stein, University of Pittsburgh
Christian D. Schunn, University of Pittsburgh

Leveraging Professional Development to Design and Enact NGSS-aligned Materials in Uncertain Policy Contexts
Carrie D. Allen, University of Colorado - Boulder
Samuel Severance, University of Colorado - Boulder
William R. Penuel, University of Colorado Boulder

Implementing Science Practices: STEM Teaching Improvement or Policy Churn?
Andrew W. Shouse, University of Washington
Kerri Wingert, University of Washington

Concurrent Session #6
All strand poster sessions.
3:15pm – 5:15pm

Poster Session A
3:15pm – 4:15pm, Riverside East

Strand 1: Science Learning, Understanding and Conceptual Change
Poster Session A
3:15pm – 4:15pm, Riverside East

A1. Have Astronauts Visited Neptune? Student Ideas about How Astronomers Study the Solar System
Christopher Palma, The Pennsylvania State University
Julia Plummer, The Pennsylvania State University
KeriAnn Rubin, The Pennsylvania State University
Alice Flarend, The Pennsylvania State University
Yann Shiou Ong, The Pennsylvania State University
Scott McDonald, The Pennsylvania State University
ABSTRACT:
This study describes the variety found in student ideas about the scientific practices used by astronomers in their study of properties of the objects that make up the Solar System. Middle-school, high-school, and college students (N=44) were interviewed about the motion of the planets, the composition of the planets, and the age of the Solar System; as a follow-up, we asked them how astronomers are able to learn about these properties. Many of the students held naive ideas, which included the assumption that humans or robotic rovers must visit planets and return samples to Earth in order for astronomers to learn about the other objects in the Solar System. Because of the challenges inherent in getting students authentic experience with telescopes to perform astronomical investigations, they often relied on their experience with the tools of other disciplines, like geoscience, to speculate about how astronomers do astronomy. Student responses rarely mentioned how astronomers develop and use models or employ quantitative thinking, suggesting that these scientific practices are not being developed in most astronomical curricula.

A3. Tensions between Conceptual and Metaconceptual Learning with Models
Michele J. Mann, University of Texas Austin
Cesar Delgado, University of Texas at Austin
Walter M. Stroup, University of Texas at Austin
Anthony J. Petrosino, University of Texas at Austin
ABSTRACT:
Models and modeling are prominent in the new US science education standards, being present as both a crosscutting concept and a science and engineering practice. Yet, there is a gap between the way scientists use models and how models are used in the science classrooms. Models have been shown to be very useful in achieving student gains in conceptual understanding of phenomena yet models may inadvertently foster inaccurate metaconceptual or epistemological understandings about the phenomenon. An evaluation of two ecosystem models was done to illustrate how these linked models could be used in the classroom to foster both conceptual and metaconceptual learning. Teachers need to be aware when using models of the conceptual outcomes as well as the metaconceptual outcomes; these are often in tension and must be navigated carefully. Students need to be exposed to multiple models during a unit that emphasize different aspects of the phenomena, supporting different conceptual understandings but also illustrating the nature of science and the

limitations and strengths of modeling. As the science education community moves towards implementing the vision of the Next Generation Science Standards, metaconceptually aware teaching practices around modeling must come into place.

A5. High School Students' Conception and Conceptual Definition in Heat Transfer

Eugene Lim, National Institute of Education, NTU Singapore
Hye-Eun Chu, Nanyang Technological University
Daniel Kim Chwee Tan, National Institute of Education

ABSTRACT:
Previous research studies indicated that students explain physical phenomena using their everyday experiences rather than scientific theories learnt in school. It is mainly due to their difficulties in making connection between their experiences and teachers' instructions. This study explores students' conceptual explanations across school years to investigate their conceptual difficulties in heat transfer. Students in Years 8, 9 and 11 taking physics subject in school were given open-ended questions and thereafter interviewed after classroom instruction. Questions were based on common daily phenomena that probe students' understanding on heat transfer concept. It was found that the percentage of students who provided acceptable scientific explanation increases with school years. Year 8 and 11 students were consistent in their responses with the former providing inappropriate scientific explanation with descriptional definition and the later providing acceptable scientific explanation with theoretical definition. To help students understand the applicability of physics theory, teachers need to consider their prior understanding and provide more daily examples during classroom instruction. Further research can be done to investigate the various types of students' explanation in heat and temperature, thermal equilibrium and state-changes.

A7. A Plausible Model? Refutation Texts Foster the Connection between Critical Evaluation, Plausibility, and Knowledge

Robert W. Danielson, University of Southern California
Neil Young, University of California, Irvine
Doug Lombardi, Temple University

ABSTRACT:
The purpose of this study was to examine how students' critical evaluation abilities and perceptions of the plausibility of contrasting theories on climate change related to their understanding of the topic. We also investigated the impact of refutation texts on plausibility reappraisal and knowledge reconstruction of climate change. Given the controversy surrounding some scientific explanations (climate change) and that plausibility is a component of conceptual change (Dole & Sinatra, 1998); we suggest that plausibility may be an underlying judgment process through which co-activation works. We hypothesized that the refutation text would activate critical evaluation and have significant influence on plausibility perceptions and knowledge post reading. Using variance-based structural equation modeling, we constructed and tested one such model. Results suggest that learners exposed to a refutation text were more likely to engage in critical evaluation, which in turn contributed to greater judgments of plausibility of the scientific explanation and predicted higher scores on the knowledge test. In contrast, learners with the expository text relied instead on their initial plausibility judgments and their prior knowledge. These results provide some support for our hypothesis that critical evaluation and plausibility perceptions promote deeper understanding of scientific knowledge after reading a refutation text.

A9. A Learning Progression on Chemical Reactions

Katrin Weber, University of Duisburg-Essen
Markus Emden, University of Education Schwaebisch Gmuend
Elke Sumfleth, University of Duisburg-Essen

ABSTRACT:

This study aims at developing and validating a learning progression on chemical reactions for the lower secondary level. Learning Progressions describe potential ways in which conceptualizing a topic might develop over time. Thus, learning progression can inform teaching fundamentally. For outlining such progressions, a strand map for student abilities in two core concepts of chemistry ("Structure of Matter", "Chemical Reactions") has been developed. The learning progression suggests that some abilities in "Structure of Matter" are prerequisite for acquiring other abilities in "Chemical Reaction". These relations will be validated in this study. Furthermore, three stages of progress are assumed for each of the core concepts, which will also be validated: Student abilities will be surveyed from grade 7-9 students in a paper-and-pencil test in multiple-choice-single-select format. This test will consist of sets of items triggering the abilities from the strand map. Correlation analyses will yield insight into these assumed relations. A validated learning progression on chemical reactions can inform educators designing efficient teaching units and curricula.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Poster Session A
3:15pm – 4:15pm, Riverside East

A11. Bringing Expert Computational Practices into High School Science Classrooms
Elham Beheshti, Northwestern University
David Weintrop, Northwestern UniversityUniversity
Kai Orton, Northwestern UniversityUniversity
Michael Horn, Northwestern University
Kemi Jona, Northwestern UniversityUniversity
Laura Trouille, Northwestern UniversityUniversity
Uri Wilensky, Northwestern UniversityUniversity
ABSTRACT:
Science is increasingly becoming a computational endeavor, as computational tools are now pervasive across the scientific disciplines and transforming scientific practices. This shift creates a pressing need to train future scientists, engineers, and mathematicians who understand how to make use of computational tools and approaches to achieve scientific goals. These skills extend beyond programming to include a larger set of skills broadly captured by the concept of computational thinking. The importance of bringing computation to science education is particularly evident from the inclusion of "Computational Thinking Skills" in the Next Generation Science Standards. To better understand how to address the challenge of preparing computationally literate scientific scholars, we conducted a study to identify how professional scientists use computation and computational thinking in their work. This work was done in support of our larger goal of defining what constitutes computational thinking within STEM disciplines. In this paper, we present preliminary findings from interviews with 15 professional STEM practitioners. The two key research questions that this study seeks to answer are: (1) what computational thinking skills are used by professional STEM practitioners? And (2) When and how STEM professionals use these CT skills in their professional lives?

A13. Digital Mapping Technology in Elementary Grades: Effects on Spatial Reasoning and Higher-Level Thinking Processes
May Jadallah, Illinois State Univeristy
Tzu-Jung Lin, Ohio State University
Sean Mullins, Illinois State University
Joel Studebaker, Illinois State University
Jonathan Thayn, Illinois State University
Alycia M. Hund, Illinois State University

ABSTRACT:
This exploratory study focuses on promoting elementary students' spatial reasoning and higher-level thinking, including systems thinking and argumentative reasoning. A total of 55 students and three teachers from three 4th grade classrooms participated in a pilot study designed to explore the effects of digital mapping technology on students' reasoning. The digital mapping technology used in the study featured Geographic Information Systems. The GIS curriculum was conducted over a two-week period in two classrooms, while the third classroom served as a business-as-usual control group. The GIS curriculum was led by a research team member in one classroom and by a teacher in the other classroom. After controlling for math and reading scores, the experimental group's performance on a National Assessment for Educational Progress geography remained the same while the control group's scores declined. The experimental group significantly outperformed the control group in systems thinking and argumentative reasoning during a cognitive interview. In this study, Spatial reasoning refers to spatial analysis, spatial representation, and spatial inference. Systems thinking concerns integrating multiple dimensions in solving a problem. Argumentative reasoning refers to the consideration of counterclaims. The findings indicate that the GIS curriculum has a potential to improve a spectrum of cognitive processes.

A15. Learning with Scientific Texts: Subject-Specific Instructions to Support Student´s Text Comprehension
Meike Rous, University of Duisburg-Essen
Martin Linsner, University of Duisburg-Essen
Angela Sandmann, University of Duisburg-Essen
ABSTRACT:
Reading scientific texts is a major challenge for students learning science. The distinguishing characteristics of academic language can hinder students´ learning and disrupt their reading comprehension. It is for this reason that students should be supported in working with scientific texts and the academic language they contain. The key objective of the study is to develop instructional materials which sustainably support learning with scientific texts. Here, we investigate the question if the form of instruction effects the achievement in content knowledge. In a 2x2-factorial design we compare subject-(biology)-specific instructions with a focus on academic language (yes vs. no) with non-subject-specific instructions which were derived from cognitive learning strategies (yes vs. no). For the further instruction there is no main effect of the experimental condition on short-term comprehension, but results show a trend that sustainable learning with a scientific text could be supported more efficiently through the subject-specific instructions rather than through non-subject specific instructions. Following analysis of think-aloud protocols and writing tasks help to interpret the results in a more detailed fashion. First analysis of the writing tasks show, that students who were instructed by biology-specific instructions draw less incorrect conclusions than students who were instructed by non-subject specific instructions.

A17. Face-To-Face Collaboration, Online Forums, and Physics Reasoning Around a Digital Game in the Classroom
Grant W. Van Eaton, Vanderbilt University
Douglas B. Clark, Vanderbilt University
Blaine E. Smith, University of Miami
ABSTRACT:
A number of studies have explored collaboration among players of recreational digital games in online forums (Gee, 2007; Squire, 2011; Steinkuehler & Duncan, 2008). Steinkuhler and Duncan (2008) in particular demonstrated the scientific habits of mind supported among players in these online forums. While research on games in classrooms is increasing dramatically (e.g., Author, in review; Squire 2005), not as much research has explored the roles of collaboration both face-to-face and in online forums in conjunction with classroom implementations of digital games for learning. The current study aims to explore the nature of physics

thinking scaffolded by naturally occurring collaboration in the classroom, as well as in online forums to which the students had simultaneous access. We observed five levels of physics reasoning across two distinct contexts – face-to-face collaboration and online forum postings. Furthermore, we found that students were three times more likely to use formal physics reasoning in online forum interactions than they were in face-to-face collaborations. Continued research should explore the impact of different interaction contexts, the goals encouraged by their structures, and the influence of classroom teachers on shaping student reasoning, reflection, and discourse.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Poster Session A
3:15pm – 4:15pm, Riverside East

A19. Leisure Friendly Intervention, Pupils' Attitude and Achievement in Basic Science
Olatunde Lawal Owolabi, Lagos State University
Peter A. Okebukola, Lagos State University
Olugbenga G. Akindoju, Lagos State University
Olukayode Akinrolabu, Lagos State University
ABSTRACT:
The study investigated the effects of music and dance on students achievement and attitude towards science. A mixed approach of quantitative and qualitative attitudes was employed using an intact classes of four schools. Instruments used for data collection were: Basic Science Achievement Test, Attitudes Questionnaire and Unstructured Interview. Data were analysed using mean and standard Deviation for the questionnaire, t-test for the achievement test and direct quotation of interviewers statements. Findings revealed that pupils showed generally more positive attitudes towards science. Also the experimental group performed significantly better than the control group.(t=5.04;df=288,p-0.00).

A21. Integrating Science and Technology: The Role of Teachers' Knowledge and Confidence
Lori A. Fulton, University of Hawaii at Manoa
Seungoh Paek, University of Hawaii at Manoa
Jon Yoshioka, University of Hawaii at Manoa
ABSTRACT:
Digital technologies are prevalent in elementary classrooms, making it easier for teachers to enact calls for meaningful integration put forth by standards for science and technology. However, teachers' knowledge and confidence with both technology and science can influence the level of integration. This case study examined one teacher as she integrated technology into her science lessons in the form of a tablet-based notebook. The teacher appeared confident as she implemented paper-based notebooks, but expressed concerns when asked to change to tablet-based notebooks. Her concerns, having more to do with management of the tablets, were overcome and she again expressed confidence in her ability to integrate both components within her science lessons. Examination of student work revealed that students' entries lacked elements that lead to greater student achievement. With such elements missing, the integration of science and technology lacked the meaningful aspect called for in the standards and did little to develop literacy in either information and communication technologies or science. While the teacher expressed concerns about the technology, our findings suggest that the larger area of concern was her understanding of the application of science notebooks.

A23. Using Mobile Inquiry Learning to Enhance Primary School Students' Conceptual Understanding in Science
Charalambia A. Lazaridou, University of Cyprus

Zacharias C. Zacharia, University of Cyprus
Lucy Avraamidou, University of Nicosia, Cyrus

ABSTRACT:
This study was designed to examine the effect of mobile inquiry based learning on elementary school students in the domain of ecology. Specifically, the goal of the study was to design and assess the effect of an indoor and outdoor intervention that involves the use of mobile devices on fourth graders' conceptual understanding of the flower, its parts and its functions. In so doing we involved 48 fourth graders in a pre-post comparison design study. The study involved two conditions, namely the experimental condition (24 students) that used mobile devices and the control condition (24 students) that used traditional means (e.g., textbook, pictures). both conditions followed the same inquiry based curriculum material. Moreover, the two conditions did not differ in any other way throughout the intervention. The data collection involved a conceptual test and students' notebooks and artefacts, The data analysis involved quantitative and qualitative approaches. Findings revealed that using mobile devices enhanced students' conceptual understanding more than using traditional means. Moreover, the students, who used mobile devices, were found to keep notes and produce artefacts that were more detailed and scientifically accurate than the students of the control condition.

A25. Science as Experience, Exploration, and Experiments: Elementary Teachers' Notions of "Doing Science"

Ashley N. Murphy, West Virginia University
Melissa J. Luna, West Virginia University
Malayna Bernstein, West Virginia University

ABSTRACT:
Researchers note that achieving fundamental change in science education requires new learning for teachers. This study focuses not on resources teachers lack, but rather on meaningful experiences science teachers have had throughout their lives, experiences that can be leveraged for teacher learning and drawn on during instruction. The aim of this study was to identify funds of knowledge around “doing science” evident in teachers’ retrospective science life stories. We identified three dimensions of “doing science” that constitute teachers’ multiple ways of thinking about what this means—their funds of knowledge of “doing science.” Understanding teachers’ funds of knowledge has important implications for supporting a shift towards reform-based practice because our findings indicate that teachers already possess funds of knowledge supporting the notion that “doing science” occurs across diverse landscapes, requires multiple habits of mind, and takes many different forms. These funds of knowledge can be leveraged as teachers begin to implement the NGSS and shift their science teaching practice.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Poster Session A
3:15pm – 4:15pm, Riverside East

A27. Measuring Science Instructional Practice: A Survey Tool for the Age of NGSS

Kathryn N. Hayes, California State University, East Bay
Christine Lee, California State University East Bay
Sara J. Dozier, Alameda County Office of Education
Jeffery Seitz, California State University, East Bay
Rachelle DiStefano, California State University, East Bay
Dawn O'Connor, Alameda County Office of Education

ABSTRACT:
As implementation proceeds for the Next Generation Science Standards (NGSS), it will be important to document shifts in science instruction towards NGSS goals, as well as additional goals described in the

literature. Survey instruments are often used to capture instructional practices, however existing surveys focus primarily on measuring inquiry based on the previous National Science Education Standards (NRC; 1996) and Benchmarks for Science Literacy (AAAS 1993). Although some surveys include items pertaining to pedagogies such as engaging prior knowledge, classroom discourse, and student reasoning, a comprehensive survey with each of these constructs and a clearly defined set of items does not yet exist. To address this need, we developed and validated a Science Instructional Practices (SIP) survey instrument, drawing on previous work to establish five themes (inquiry and experimentation, reasoning and argumentation, science discourse and communication, engaging prior knowledge, and traditional practices) critical for science instruction in the age of NGSS. This study presents data from a first field test of the SIP instrument, including reliability and construct, content, and criterion validity. Overall, we present a valid and reliable survey that measures a range of science instructional practices at a relatively granular level, including NGSS practices.

A29. A Cross-Cultural Comparison of US and Korean Science Teachers' Perceptions and Approaches towards Misconceptions

Kyungwoon Seo, University of Iowa
Soonhye Park, University Of Iowa
Aeran Choi, Ewha Womans University

ABSTRACT:

A critical component of teacher effectiveness is how teachers perceive students' misconceptions and adjust the instructional approach accordingly. Taking a stance that the teachers' instructional quality is crucial on its impact on students' learning, a qualitative comparative study was performed to compare such characteristics of science teachers in the US and South Korea ,where the constructivist view of learning are shared and yet substantial differences in students' achievement outcomes in international standardized assessments are exhibited. A web-based on-line survey consisting of open-ended questions on teaching photosynthesis at a secondary level was administered and 85 and 81 teacher responses were collected from the US and Korea, respectively. Adopting grounded theory as the methodological framework, constructed responses were analysed using the constant-comparative method. Four categories emerged from analysing teacher perceptions: Content, Curriculum, Student Knowledge, and Pedagogical Perspective. In terms of instructional strategies, two dominant patterns emerged: teacher-centered and student-centered. Teachers from both countries demonstrated more frequent use of teacher-centered approaches, although the patterns of the usage in relation to their perceptions of misconceptions were different to some extent between the two countries. Interpretations of the results are further discussed in relation to the differences in science education context and teacher preparation systems.

A31. Improving At-Risk Students' Attitudes toward Science and Science Instruction with Inquiry-Based Science Activities

Sarah Watt, Miami University
Nazan U. Bautista, Miami University

ABSTRACT:

This study was exploratory in nature and examined attitudes of students with disabilities and those who are at-risk of failing school toward, and their interest in, science and science instruction when participating in either traditional or place-based structured inquiry science instruction. Twenty 8th graders who were identified as “students with disability” or “at-risk of failing school” and enrolled in one of the sections of T-town Middle School Connections (TMSC) Program were invited to participate in the study. The students in the second section were identified as the control group to be able to clearly determine the effect of the place-based structured inquiry instruction on participants’ attitude toward and interest in science. The results of this study reveal that place-based structured inquiry instruction does make a difference in the struggling learners’ attitudes toward science and science instruction. However, it seems that improving their interest in science takes longer and requires more engagement of students in this type of science instruction. Study has implications for science teacher educators, special education faculty, and education researchers.

A33. How Teachers Negotiated the Meaning of NGSS through Participation in a Professional Learning Community

Ellen Barnett, University of Missouri
Patricia J. Friedrichsen, University of Missouri-Columbia

ABSTRACT:
Next Generation Science Standards (NGSS) provide a new vision for science education, but teachers implementing NGSS will need to develop an understanding of the reforms and design curriculum that is consistent with it. Professional learning communities (PLCs) are a potential venue for providing teachers the collaboration time that literature suggests is needed for teachers to re-envision their practice; yet, there are few studies of mature PLC's in science education. The purpose of this study was to describe how reform-oriented secondary biology teachers participated in a mature, effective PLC as they negotiated the meaning of and implemented NGSS. Interviews, audiotaped PLC meetings, email communications and observation notes were analyzed. While each teacher contributed in unique ways, it was in working together and with other communities that teachers were able to negotiate the meaning of the new standards and begin to redesign their curricula. These findings fill a gap within the literature because they shed light on science teachers' collaboration within a mature PLC and teachers'current science education reform efforts. Implications include the need for policies that foster teacher collaboration and future research that explores how science teacher communities' interactions with others influences reform efforts.

A35. Second Career Science Teachers Reflections on the NGSS Science Practices

Allison Antink-Meyer, Illinois State University
Ryan Brown, Illinois State University

ABSTRACT:
Due to their professional experiences in science careers as well as in science classrooms, much may be learned from the exploration of second career science teachers' classroom practices and perceptions. Existing studies of this group of teachers have generally focused on their transition from science practitioner to educator (Powell, 1994, 1997). This investigation excluded novice science teachers who may still be grappling with the transition into teaching. The participants of interest were those who: 1) completed certification post-baccalaureate, 2) possessed a bachelors or terminal degree in a science or engineering discipline, 3) who had at least two years of full time professional experience in a science or engineering field (a benchmark used in other, related studies) and 4) who have completed at least three years of full time classroom teaching. Two research questions guided this investigation. 1) What relationships exist between second career science teachers' STEM backgrounds and their interpretations of the science and engineering practices in the Next Generation Science Standards (NGSS) (NGSS Lead States, 2013; NRC, 2012)? 2) What are the potential relationships between second career science teachers' science and engineering backgrounds and their classroom practices related to the science and engineering practices?

A37. The Impact of Science Teachers' Orientations on their Understanding and Implementation of Interdisciplinary Science Inquiry

Erica L. Smith, State University of New York at Buffalo
Xiufeng Liu, State University Of New York At Buffalo (SUNY)

ABSTRACT:
This study was situated in a NSF-funded teacher professional development project between two universities and a school district in the North Eastern United States. As part of that project and within the framework of science teacher pedagogical content knowledge, this study explored (1) the nature of in-service science teachers'

orientations and whether they changed as a result of being involved in the project, and (2) did their orientations influence their understanding and implementation of interdisciplinary science inquiry. This qualitative study utilized a descriptive case study approach. Results of this study found that a major factor to how teachers implemented ISI was the coherence between their orientations towards teaching science and the aspects of ISI. Teacher-centered and traditional orientations served as a stumbling block for the implementation of ISI. However, those with an inquiry-based orientation were able to make changes in their practice as evidenced by the implementation of new activities, skills and technology and an increased effort to establish connections between science content and their students' lives. The findings of this study have implications in aiding in the alleviation of the dissonance between in-service science teachers' orientations and the reform-based practices of NGSS.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Poster Session A
3:15pm – 4:15pm, Riverside East

A39. Developing, Supporting, and Sustaining a National Professional Developer Network to Enhance Undergraduate Biology Education
April Cordero Maskiewicz, Point Loma Nazarene University
Gili Marbach-Ad, University Of Maryland
Deborah Allen, University of Delaware
Susan Elrod, California State University Fresno
Karen Sirum, Bowling Green State University
Gordon Uno, University of Oklahoma
ABSTRACT:
This proposal describes how we foster collaboration, exchange of ideas, and research initiatives regarding undergraduate biology faculty development (FD) through a vital community of practitioners and scholars. Our Faculty Developer Network for Undergraduate Biology (FDN-UB), an NSF-funded Research Collaboration Network, is a national effort to improve undergraduate biology education. Progress towards fundamental changes in undergraduate biology education is presently hampered by limited interaction between biology researchers and teachers, education researchers, and biology FD leaders. The FDN-UB is designed to bring coherence to the current, disparate field of professional development (PD) in biology. With a focus on PD directly related to content, pedagogy, and assessment of learning, the network is answering three general questions: (a) what does the research tell us about faculty PD and what are the gaps in this knowledge? (b) What can we learn from existing PD about state of the art teaching practices, successful PD programs, and evaluation methods? And (c) how can we sustain change that was instantiated in an institution, college, department or an individual course? Our findings will contribute resources, mechanisms, and research-based strategies to the broader community. Our presentation will showcase models for successful programs, which could be adopted by NARST members.

A41. Professional Development for Biology Graduate Teaching Assistants: Status, Challenges and Needs
Gili Marbach-Ad, University of Maryland
Elisabeth Schussler, University of Tennessee
Kristen Miller, The University of Georgia
Miriam Ferzli, North Carolina State University
Quentin D Read, University Of Tennessee
ABSTRACT:

This proposal presents the efforts of the Biology Teaching Assistant Project (BioTAP), an NSF-funded research coordination network, to improve professional development (PD) of biology Graduate Teaching Assistants (GTAs). The main mission of the network was to assess, at a national level, the current status of biology GTA PD. To this end we developed a survey to compile information on the current needs in and challenges of providing PD for biology GTAs. The survey, sent to individuals responsible for training biology GTAs at their undergraduate research institutions, consisted of 20 questions (11 closed-response and nine open-ended). Overall, 85 respondents from 71 different institutions completed the survey. Encouragingly, survey results indicated that 91% of institutions provide some sort of formal teaching preparation for biology GTAs; however, 50% implemented 10 or fewer hours of this PD. Additionally, little pedagogical preparation is provided, and there is a lack of teaching support and meaningful feedback for the GTAs. Further analysis identified a statistically significant correlation between total hours of PD per GTA and programmatic perception of institutional support and satisfaction with PD. We identified approaches that could serve as models for GTA PD, and we will share these examples in the conference.

A43. Undergraduate Students' Sources and Perceptions of Scientific Information

Sanlyn Buxner, University of Arizona
Chris D. Impey, University of Arizona
James Romine, University of Arizona
Megan Nieberding, University of Arizona

ABSTRACT:
We report on a study of 400 undergraduate non-science majors to understand where they report getting their information about science, how they rate the reliability of that information, and their perception of scientific knowledge. We found that most students' self-reported interest in and knowledge of science were directly related to their future career plans, except for those intending to become elementary teachers who were split between high and low in both interest and knowledge. Students reported gaining most of their information about science from internet searches, other online sources such as Wikipedia, and through assigned class readings. They reported the most reliable sources of science information to be professors, textbooks, researchers and science related sites (e.g. NASA). Although there was no pattern between students' basic science knowledge and where they reported getting information about science, there was a relationship between the sources they considered to be the most reliable and their overall science knowledge. Our results suggest the need to increase students' information literacy to support them in being informed consumers of science.

A45. Essential Features and Benefits of Undergraduate Research Experiences: Perspectives of Student Researchers and Practicing Scientists

Joseph A. Harsh, James Madison University
Russell N. Balliet, Indiana University
Adam V. Maltese, Indiana University
Robert H. Tai, University of Virginia

ABSTRACT:
Within the sciences, undergraduate research experiences (UREs) are widely touted as one of the most powerful educational devices to develop student skills and STEM interest. However, while prior literature has outlined various participant gains and important URE characteristics, current knowledge is largely based on anecdotal accounts and data from active participants at single institutions/programs, which may limit generalizability and the ability to draw linkages between UREs and educational enhancements as students may not be able to put such experiences into proper professional context. Using interview and survey data from two national studies in the physical sciences, this work offers a comparative analysis of the short- and long-term outcomes and features of UREs that maximize learning as perceived by student researchers (n=212) and former participants (n=3041) now in research-related careers. Results of the study revealed a range of conferred gains to URE participants,

and how the value of these experiences may change over one's career. As well, respondents highlighted ten essential programmatic features to support learning, including mentorship strategies and research-related activities. This analysis advances URE literature by providing further information on the transition from student to scientist, which is crucially important in preparing students for STEM careers.

A47. Experiential Learning in the Plant Sciences through Augmented Reality

Selcen Guzey, Purdue University
Thomas Michaels
Eric Watkins

ABSTRACT:
Undergraduate plant science education should prepare students to extend and integrate their knowledge in new situations and with other disciplines to solve problems effectively. In this study, we provided opportunities to actively learn plant sciences through field experiences enhanced by augmented reality (AR) - virtual overlays of information displayed on smartphones and other mobile computing devices. We investigated the impact of two AR field experiences on learning, particularly the integrated learning required of new biologists, and on student interest in transferring to, or continuing study in the plant sciences. Findings showed that students found the AR experiences very helpful in learning the content of a Plant Propagation course (HORT 1001) that enrolls over 250 students in a large Midwestern university. Student survey responses and feedback used to revise the two AR games developed by the authors.

A49. College Students' Perspectives and Reasoning about Over-The-Counter and Internal Health Monitoring Devices

Eva Erdosne Toth, West Virginia University
Paula Witt-Enderby, Duguesne University
Joey Fama, West Virginia University

ABSTRACT:
This study examined pharmacy students' perspectives about the risks and benefits of over-the-counter (OTC) and internal (INT) health monitoring devices. The results indicated that students had a generally positive perspective about these products. However, they struggled to balance their positive perspectives with the complexities of counseling patients about the use of these tools. Students' reasons indicated their attempts to consider factors of practical benefit, equal access as well as difficulties of predicting human action. However, without detailed instruction the majority rationales simply focused on the practical aspects of using such devices and on world-views about the benefit of machines to assist humans. The results support the formulation of innovative classroom pedagogies thus promise to be of interest to NARST members.

Strand 6: Science Learning in Informal Contexts
Poster Session A
3:15pm – 4:15pm, Riverside East

A51. Minority Engagement in Science Hobbies: Discussion of Social Barriers, Motivation Influencing Science Self-efficacy and Identity

Rebecca Hite, North Carolina State University
M. Gail Jones, North Carolina State University
Thomas Andre, Iowa State University
Gina Childers, North Carolina State University
Elysa N. Corin, North Carolina State University

ABSTRACT:

Women and minorities have been historically underrepresented in science fields. Despite changes in policy and targeted educational outreach, disparities persist among women and minority groups selecting a STEM based career. Current research explores the formation of STEM identities and efficacy in under-represented of groups in both formal and informal educational settings. However, there is little research about out of school experiences with STEM such as science hobbies. The goal of this study was to look closely at underrepresented minority amateur astronomers to develop insight into their hobby activities including challenges and benefits to them as leisure activities. Of special interest in this study was the pathways that hobbyists followed including factors that influenced their motivation to continue to practice their hobby and the influences on the development of their hobby expertise. Themes emerged through hobby discussions included sociocultural factors of developing science identity and development of self-efficacy as well as institutional barriers regarding access and income. The information gained from these case studies can inform policy and future research related to the lack of minority STEM hobbyists nationwide.

A53. Night at the Museum: Learning to Teach in an Informal Setting

Stacey Britton, University of Mississippi
Qiang (Andy) Cheng, University of Mississippi
Renee Hill-Cunningham, University of Mississippi
Amber Carpenter-McCullough, University of Mississippi

ABSTRACT:

Although informal learning has been recognized as a meaningful way in which students acquire new knowledge and skills that are often difficult to gain from formal learning contexts, studies focusing on the impact of informal learning on pre-service teachers' learning to teach are limited. Guided by Situated Learning Theory, the current study examined how chaperoning middle school students on a two-day field trip impacted pre-service teachers learning to teach. Results indicated that the participating teacher candidates gained confidence in chaperoning and facilitating students in informal learning contexts, acquired first-hand knowledge and understanding about how to effectively managing field trips, and obtained important insights regarding student learning behaviors and how to apply such insights to teaching their own students in future classrooms. Findings of the study have important implications for teacher educators and school practitioners regarding how to better use informal learning opportunities in the preparation of pre-service teachers for planning and enacting field trips with middle school students.

A55. Improving Interest and Self-Concept in Science through Indoor Urban Farming

Amie K. Patchen, Boston College
Janet Lorden, STEM Garden Institute
Lin Zhang, Providence College
Mike Barnett, Boston College

ABSTRACT:

Our work has focused on building an out-of-school time indoor urban agriculture program targeting upper elementary students. Extensive research has documented that low-income and ethnic minority students under perform and are underrepresented in STEM. Additionally, low-income and minority neighborhoods have reduced access to fresh produce and higher barriers to healthy eating than other neighborhoods, which has been found to negatively impact school performance. To address this, we have developed a year-long hydroponic program where youth grow produce year-round and are responsible for caring for their produce, determining what crops to grow, and the optimal growing conditions for different crops. The growing and eating of food is an intellectual area that most youth can relate to, particularly recent immigrants who may have significant previous agricultural-related experiences. Survey and interview data on student interest, attitude, and self-concept toward science from three sites (n=234) during the first year of the program will be presented. Our results suggest that hydroponics offers the opportunity for students to make an easy pathway into learning

science, particularly for non-native speakers and for girls, which in turn can greatly enhance their desire to study science and improve their self-concept toward science.

A57. It Takes a Village to Raise a Scientist: An After-School Urban Partnership

Carolyn A. Parker, The John Hopkins University
Yolanda Abel, The Johns Hopkins University
Audrey Moshfeghian, The Johns Hopkins University

ABSTRACT:
In this presentation, we present an approach to science education that builds expertise and excitement for science learning within three distinct urban communities by engaging teachers and students in grades 3-5, caregivers, community based-organizations, after-school program operators, faculty and students from a university, members of the city's businesses, and museums. A fundamental premise that undergirds the work is that the integration of science into the learner's world, as opposed to bringing students into the world of scientists, has great potential to enable authentic science learning. We will discuss how the adoption of a community-based science approach is influenced by the synergy of neighborhoods and schools, such as community support, neighborhood resources and infrastructure, and school organization. Student surveys and videos interviews will be analyzed as evidence of our work.

A59. Experiment-Based Science Learning in a Mobile Laboratory

Mustafa Erol, University of Bozok
Ugur Buyuk, University of Erciyes
Nagihan Tanik, University of Erciyes

ABSTRACT:
The low rate of experimental activities in science courses in rural parts of Turkey negatively effects students' acquisition of scientific thinking and inquiry skills. The fact that success rates are notably low in science examinations in PISA and TIMSS features the necessity to do "different" things apart from the existing learning and teaching methods. From this point of view, a mobile science laboratory was constructed to deliver outreach activities. Experimental activities were carried out in this mobile laboratory for six months for 324 secondary school students in the rural area. The students who participated in the activities evaluated the study. The research was designed with one group post-test model. The data were gathered by a form consisting of two parts. The first part has 25 five-point Likert-type items and the second part has two close-ended questions. Quantitative data were analysed by descriptive statistics and qualitative data were analysed by descriptive analysis approach. The results of the study show that the students are pleased with the activities, they learned entertainingly in the mobile laboratory and their interest and curiosity for science course increased.

A61. Me? A Scientist: A Next Generation of Students Internalizing Their Identities as Scientists

Lauren M. Shea, University of California, Irvine
Therese B. Shanahan, University of California - Irvine
Stacey Freeman, University of Arizona

ABSTRACT:
There recently has been much discussion nationally about the integration of Science, Technology, Engineering, and Math (STEM) in education. With the adoption of the Next Generation Science Standards (NGSS), science educators are looking to purposefully incorporate science and engineering practices into informal science experiences for children. Additionally, with NGSS, science educators are shifting the focus of their programs to provide opportunities for children to do science like scientists. But the question remains as to how they will encourage low income children to identify themselves as scientists. This mixed-methods research study addresses the question to what extent does an afterschool program that emphasizes "acting like a scientist" alter students' perceptions of scientists and promote students' identity as a scientist? The findings suggest that

informal providers must be very intentional in their questioning, discourse and acknowledgement of instances when children are acting as scientists during science lessons. The authors posit that solely engaging in well-constructed science lessons is not enough to internalize gaining an identity as a scientist.

A63. Characterizing the Development of Students' Ability to Ask Questions in a Merged Formal/ Informal Program

Tom Bielik, Weizmann Institute of Science
Anat Yarden, Weizmann Institute of Science

ABSTRACT:
There is an ongoing call for bridging the gap between in-school formal science learning with out-of school informal science environments. In this research, we present an innovative high-school program in biotechnology, called the 'Bio-Tech', which merges in-school formal learning with an informal learning environment in an outreach facility of a scientific research institute. Asking questions is a fundamental scientific practice, and students are expected to formulate their own researchable question while performing scientific inquiry. We set to explore the possible development of students' ability to ask researchable questions in the Bio-Tech program and examine a peer-critique activity that was carried out during a classroom lesson, in which students learn to formulate researchable questions. We found that participation in the Bio-Tech program developed students' asking questions practice and that the peer-critique activity was meaningful for students' learning of this practice. This is important for promoting the teaching and learning of asking questions in educational programs that bridges formal and informal environments. We suggest that innovative programs, such as the Bio-Tech, in which students learn to formulate their own researchable questions in a peer-critique activity, may promote the development of students' asking questions practice.

Strand 7: Pre-service Science Teacher Education
Poster Session A
3:15pm – 4:15pm, Riverside East

A65. The Will of the Ancestors Phase II: Sociocultural Understandings in Teacher Preparation and Science Education.

Cecilia Andrews, Kashunamiut School District
Flora Ayuluk, Kashunamiut School District
Megan Marquis, University of Alaska Anchorage
Irasema Ortega, University of Alaska-Anchorage
Neva Mathias, Kashunamiut School District, Chevak Alaska

ABSTRACT:
This manuscript presents a narrative and analytical account of the second phase of a four- phase initiative that focuses on the preservation of language, culture and place through Indigenous ways of knowing in science. We share the experiences of an elementary preservice teacher and a science education faculty member who collaborated with Native American elders, parents, teachers, and students to design and prepare an atlas of plants and animals based on traditional knowledge of subsistence practices. Phase one of the project is an ongoing cooperation between Native American teachers and elementary education faculty from a state university in the Northwestern Unites States. The corpus of data consists of field notes and recorded conversations and interviews with members of the community who participated in the project. The results of this experience indicate that members of the community provided valuable information and guidance used in the preparation of the atlas. Furthermore, through this project, a preservice elementary teacher and a faculty member learned to collaborate with members of the community and gained valuable insights regarding the characteristics of shared cognition of ancestral Indigenous knowledge of place, culture and language.

A67. Huddle Up: Enactment of Coteaching in Science Classes
Kathryn Scantlebury, University of Delaware
Kyle Chismar, Redding Middle School
Kaitlin Craig, Redding Middle School
Matthew Juck, Middletown High School
Susan Gleason
ABSTRACT:
This research examines the characteristics and frequency of huddles between teacher candidates and cooperating teachers during student teaching in science when coteaching is enacted. Huddles occur during the science lesson when two or more teachers meet to discuss lesson enactment. Types of huddles include: redirection, extensive thinking, student understanding, corespect, logistics, student specifics and lesson evaluation. Three cooperating teachers and university personnel examined ten hours of videoed science lessons and reviewed interviews and transcriptions of research meetings. A majority of the huddles used by the teachers included: Redirection, extensive thinking, corespect and lesson evaluation. Teachers used huddles on a regular basis to facilitate lessons and provide teacher candidates opportunities to evaluate on-going instruction.

A69. Elementary and Secondary Pre-service Teachers' Science Content Knowledge and Conceptions of Nature of Science
Tonya D. Jeffery, Texas A&M University - Corpus Christi
Cherie A. Mccollough, Texas A&M University - Corpus Christi
Kim Moore, Texas A&M University - Corpus Christi
ABSTRACT:
This mixed-methods study investigates elementary and secondary pre-service teachers' (PSTs) (n=12) science content knowledge and conceptions of nature of science (NOS) following the first year implementation of a STEM site-based professional development (PD) program. Three research questions were used to guide this study: (1) To what extent did pre-service teachers' science content knowledge change over the program period? (2)To what extent did pre-service teachers' views of NOS change over the program period? (3) What are the similarities and differences between elementary and secondary pre-service teachers' conceptions of NOS? The VNOS-C instrument (Lederman, Abd-el-Khalick, Bell, & Schwartz, 2002) was utilized to collect data regarding participants' NOS conceptions before and after the intervention. Pre- and post-test data from a science content exam (Wynne, 2008) was used to assess changes in content knowledge. Findings in this study highlight the need to foster and develop PSTs science content knowledge and explicit understandings of NOS in teacher preparation program coursework. Furthermore, findings can inform the design and implementation of curricula and programs that promote understanding of NOS at the pre-service teacher level, and subsequently professional development programs at the in-service teacher level.

A71. Fostering Pre-service Teachers´ Professional Vision in Primary School Science Classes
Cornelia Sunder, Westfälische Wilhelms-Universität Münster
Maria Todorova, Westfälische Wilhelms-Universität Münster
Kornelia Möller, Westfälische Wilhelms-Universität Münster
ABSTRACT:
Professional vision is considered to be a central component of teaching expertise, and it is regarded as fundamental for acting professionally and reflecting in classrooms (Sherin, 2007). Studies on mathematics and science instruction show a positive correlation between teachers‘ professional vision and students‘ performances (Kersting et al., 2012; Roth et al., 2011). This raises the question of how professional vision can be fostered in teacher education. For this purpose, video-based teaching/learning environments are often used regarding different groups and domains (Blomberg et al., 2013). In primary school science education, there is a

lack of controlled studies investigating the efficiency of such learning environments. In the present study, a case-related video- and text-based program (n=32) has been compared to a case-related, text-only based program (n=36), and to a control group without case-based learning elements (n=16) in order to foster the professional vision of undergraduate students concerning learning support including aspects of cognitive activation and content-related structuring. To measure professional vision, a standardized video test was applied. Initial results of our study show that the group additionally trained with videos could outperform the other two groups in professional vision regarding the topic trained in both case-related programs.

A73. What are Science Teachers? The Identity Discourse of Preservice and Inservice Teachers
Pei-Ling Hsu, University of Texas at El Paso
Angelica Monarrez, University of Texas at El Paso
ABSTRACT:
Throughout this paper, we analyzed preservice and inservice science teachers' identities in an effort to understand and compare their own views of their self-evaluation as science teachers. We used identity theory as an analytic lens to help us understand the salient themes in analyzing identities involved in science teaching and learning. To help us understand the identities revealed on the preservice and inservice science teachers' narratives we draw on James Paul Gee's (2000) theoretical framework of identity theory. In this qualitative study, we interview and analyze 13 preservice science teachers and 13 inservice science teachers. Results show that inservice teachers want more autonomy of their classrooms while preservice teachers are more dependent of the curriculum and other institution aspects.

A75. Teaching SSI at Primary School: Insights and Challenges from a Pre-service Teacher Education Program in Spain
Digna Couso, Crecim-Universitat Autonoma de Barcelona
Anna Garrido, Crecim-Universitat Autonoma de Barcelona
ABSTRACT:
The importance of introducing socioscientific issues (SSI) in science teaching is strongly recognized in the literature. Literature in the field, however, is moslty focused on students' decision-making abilities, conceptual understanding and engagement with science, being teacher education in the field a rather unexplored area. In this presentation, we will discuss our findings regarding the introduction of an innovative teacher education program on SSI in the context of a EU project. The program focus on recognizing the inherent uncertain and controversial aspects of everyday science; the recognition of the Nature Of Science regarding the existence of controversy and uncertainty within Science, and the different types of arguments that can be used when discussing or deciding about SSIs. Student teachers pre and post elaborations and reflections regarding their conceptualisation of SSI and their appreciation of its value in science education have been analysed. Initial findings show that, despite the improvements made within the program, more emphasis in certain aspects of SSI teaching and learning is needed, in particular the controversial nature of SSI and their importance for learning science and about science. Future work will include the analysis and finding of pre-service teachers' challenges when teaching SSI in actual primary schools.

A77. Exploring Prospective Middle-School Teachers' Knowledge and Beliefs about Engineering Design and Its Teaching
Dongmei Zhang, The University of Georgia
Barbara A. Crawford, The University of Georgia
ABSTRACT:
The new science education framework (NRC, 2011) and standards (Achieve, 2013) added engineering design (ED) to science practices. How to help prospective teachers prepare for this new task is one of the imperative problems faced by science teacher educators. In this paper, we introduce a case study which aims to explore 18

prospective middle-school teachers' knowledge and beliefs' about ED and its teaching developed by experiencing an ED unit in a methods course. The data included pre-survey, teamwork sheets, lesson plans, two reflections, and interviews. This study had several findings. First, participants had little knowledge about ED and its teaching due to their insufficient prior ED experiences. However, most participants held positive beliefs towards ED and its teaching based on their non-engineering design experiences. Second, engaging in design activity appeared to be useful in helping prospective teachers develop their knowledge and beliefs about ED and its teaching. Finally, in order to develop knowledge and beliefs effectively, the design activities should be carefully-designed and align with how the activities could be used in classrooms. In addition, prospective teachers need multiple and diverse ED experiences.

A79. Emerging Understandings of Assessment: Pre-service Elementary Teachers in a Science Methods Course

Sara Nelson, Iowa State University
Eunjin Bang, Iowa State University

ABSTRACT:

This research is a work-in-progress and part of a larger study that investigates the professional journey of pre-service elementary teachers in science education. It focuses on the role of assessment in scientific inquiry and the implementation of assessment practices by pre-service elementary teachers. Data sources include archived reflective science journal entries from 25 pre-service teachers. Results of initial data analysis indicate a need for continued focus on effective design and implementation of assessment in the elementary classrooms for pre-service science teachers.

Strand 8: In-service Science Teacher Education
Poster Session A
3:15pm – 4:15pm, Riverside East

A81. Conditions that Support Lesson Study for Integrating NGSS in Science Classrooms

Christine Lee, California State University East Bay
Kathryn N. Hayes, California State University East Bay
Rachelle DiStefano, California State University East Bay
Jeffery Seitz, California State University East Bay
Dawn O'Connor, Alameda County Office of Education

ABSTRACT:

Lesson Study (LS) shows immense promise for supporting the instructional shifts proposed by NGSS. Specifically, LS can serve as a vehicle for teachers to align their instruction to educational standards while keeping the unique needs of their students at the forefront of their decision-making (Darling-Hammond & Ball, 1998; Lewis, 2002). However, there is a gap in the literature on the systemic factors that influence the implementation and scaling of LS (Lewis et al., 2006; Perry & Lewis, 2009). To address this gap, this study draws upon the conceptual framework for scale-up proposed by Glennan (2004) to examine the contexts which create the conditions for spread, depth, sustainability, and shifts in ownership regarding middle school science LS. The research question guiding this study was: What conditions support middle school science LS implementation fidelity and scale towards sustainability? Results showed that differing organizational structures and cultural approaches within the six case districts led to different levels of success in achieving the conditions for LS to be maintained for long-term, coherent science education reform. Overall, findings highlight factors that contribute to district and schools ability to implement and scale science LS in the current age of NGSS and Common Core reform.

A83. Science Teachers' Perceptions of the Evaluation of their Professional Development Programs

Saeed Alshamrani, King Saud University Saudi Arabia
Nasser Mansour, University of Exeter
Saeed Alghamedi, Jouf University Saudi Arabia
Abdulwali H. Aldahmash, King Saud University Saudi Arabia
Saed Sabah, The Hashermite University, Jordan

ABSTRACT:
This paper aimed to identify the perceptions of high school science teachers regarding the evaluation of perceived professional development (PD) program through identifying the actual evaluation levels and their importance in the light of Guskey model. To collect the data, the researchers developed a questionnaire with four domains. The content and face validity were assured, then the questionnaire was administered on a pilot sample of 71 science teachers. The final version was administered on a sample consisting of 1693 high school science teachers in four educational administrations; the responses was 377 from male and female teachers. The results indicated that the five aspects in Guskey model was covered with moderate means in PD programs with slight variations among these aspects; moreover, the results revealed that the science teachers believe that all aspects of PD program evaluation are important.

A85. Designing a Measure of Teacher Belief about Student Ability to Engage in Scientific Argumentation

Rebecca Katsh-Singer, Boston College
Amanda M. Knight, Boston College
Maria Gonzalez-Howard, Boston College
Katherine L. Mcneill, Boston College

ABSTRACT:
Scientific argumentation is an essential practice for students, yet little research has explored teachers' beliefs about students' capabilities to engage in argumentation. In this study we describe the development of an instrument to measure this construct as well as the results from a recent pilot with 103 middle school science teachers. Given the limited research base, we use empirical results to develop a hypothetical construct map of teachers' beliefs about students' capabilities to engage in argumentation. Our instrument asked teachers to state how capable they believed eight fictional students with specific backgrounds or abilities would be to engage in argumentation. Specifically, we explored the following research questions: 1) What are teachers' beliefs about students' capabilities to engage in argumentation? 2) What are the characteristics of items that are easier and more difficult for teachers? While all items were easy for teachers, our results suggest that teachers are less likely to believe ELL students and struggling readers are capable to engage in argumentation. These findings indicate that future pilots should include more difficult items. In addition, these results could inform the types of supports that may be necessary for all teachers to successfully implement argumentation in the classroom.

A87. The Impact of a Multi-level Genomics PD Program on HS, Community College, and University Faculty

Caren Gough, Stony Brook University
Amy Nisselle, DNA Learning Center, Cold Spring Harbor Laboratory
Minsu Ha, Kangwon National University
Ross H. Nehm, SUNY Stony Brook

ABSTRACT:
This proposal explores the impact of a large-scale PD program (> 200 teachers) focused on the "New Biology." In particular, it examines the efficacy of using multi-group PD (groups of High School, Community College, and University Faculty teachers) to learn and teach genomics and bioinformatics concepts. Many teacher PD programs focus on particular concepts in particular grade bands; however, mixing teachers from multiple educational levels could provide an effective PD strategy, but little research has explored this issue. Specifically, our study examined: (1) whether participants demonstrated changes in knowledge and confidence in teaching genomics and bioinformatics after completing the PD workshop "Genomic Approaches in the

Biosciences"; (2) Whether HS, CC, and UF teachers displayed similar or different outcomes; and (3) Whether HS, CC, and UF teachers viewed this multi-group PD format to be beneficial. Tests for differences among teacher levels (HS, CC, UF) were analyzed using Chi square and ANOVAs depending on the type of response. Focus groups were also used to gain insights into the impact of the PD program on teachers. Overall, all statistical comparisons revealed comparable gains across teacher groups, and focus groups corroborated the quantitative results and showed that participants viewed this multi-level approach as beneficial.

A89. Research Experiences for Teachers: Engineering Applications in Science and Math Classrooms
Jessica Stephenson, Virginia Tech
Brenda R. Brand, Virginia Tech University
Christopher Willliams, Virginia Tech
ABSTRACT:
There is a demonstrated need for advancing the United States' manufacturing presence in the global innovation economy. The primary goal of the Research Experiences for Teachers program in specialized manufacturing centers (RET:SMC) is to make significant steps towards improving the youth's perception of engineering and manufacturing by providing opportunities for teachers to engage in cutting-edge manufacturing research topics that are rich with contextual examples of STEM principles. Funded by the National Science Foundation, this six-week summer program partners middle and high school STEM teachers with Research One engineering faculty to research topics in the area of advanced manufacturing. In addition to research, participants will engage in professional development activities that are geared toward helping the teachers to successfully translate their research experience into inquiry-based classroom modules. We will discuss teacher experiences and curriculum projects, lessons learned, and emerging data from the program.

A91. Social-Cognitive Reform Information Processing Typologies (S-CRIPT): A Model for Understanding Teacher Change
Daniel M. Alston, Clemson University
Jeff C. Marshall, Clemson University
Eric McKibben, Clemson University
ABSTRACT:
Science education is currently in the process of another reform movement being led by the Next Generation Science Standards (NGSS). These standards call for teachers to engage in a higher level of constructivist-style teaching in order to get all students to achieve at a higher level. In order for teachers to engage in higher quality constructivist style teaching, teachers once again find themselves becoming learners in professional development (PD) programs, geared towards instructing teachers on how to create constructivist-style classrooms. While evidence suggests that PD frequently aids in teacher growth and behavioral change, not all PD brings about the same results in all teachers, indicating that individual differences among the teachers play a significant role in altering teacher behavior. Psychologists, such as Mischel and Shoda state that situations, along with individual differences in person variables, are crucial in understanding behavior. Mishcel and Shoda combined these ideas into a metatheory which they refer to as the cognitive-affective personality system theory (CAPS). This paper utilizes this social-cognitive-affective perspective in order to review literature on science teacher implementation of constructivist reform-based practices in order to develop a model to better understand teacher change.

A93. Professional Development Programs: Teacher's Perceptions
Hiya Almazroa, Princess Noura University
Abdulrahman A. Aloraini, Ministry of Education
Fahad S. Alshaya, King Saud University
ABSTRACT:

The purpose of this study was to describe the development and application of an instrument to identify various dimensions of professional development. Perceptions of science and mathematics teachers about the design of the professional development during the first year implementation of the new curriculum were explored. A questionnaire was developed by the authors for this research to measure teachers' perceptions regarding issues of professional development. The questionnaire included five dimensions of effective professional development programs which relate to goals, content, support, approaches, and evaluation and research sample included (1999) science and mathematics teachers scattered around the country. The findings show that the respondents were not satisfied with the preparation they were provided with to teach the new science and mathematics curriculum. Results point to weaknesses in professional development quality, teacher's perceived emphasis of their respective PD in all dimensions were rated medium, and the evaluation dimension received low rating. Recommendations were provided to improve teacher professional development.

A95. Using the Views about Science Inquiry Questionnaire as a Reflective Tool to Impact Teaching Practice
Jennifer C. Parrish, Middle Tennessee State University
Stephen A. Bartos, Middle Tennessee State University
Kim Cleary Sadler, Middle Tennessee State University
ABSTRACT:
This study examined changes in 5th grade students' understandings about scientific inquiry using the Views About Science Inquiry Instrument (VASI) after completing an open-ended inquiry investigation along with explicit instruction on scientific inquiry, including argumentation. Additionally, since very few teachers have used the VASI questionnaire, the other focus of this study was on the use of VASI as a tool to facilitate the teacher's self-reflection regarding her classroom practice and its impact on students' understandings of inquiry. The VASI questionnaire was administered in a pre- and post-survey design and after analysis of the data, the researcher interviewed the teacher to discuss changes in student VASI responses for high, medium, and low ability students. Results from this exploratory study showed some positive changes in students' understanding of scientific inquiry, but also indicated that low and mid-level students regressed more than high-level students in their understanding of inquiry. The teacher saw the VASI questionnaire as a valuable reflective tool that she could utilize to inform her instruction and incorporate in professional development opportunities for her teams of elementary teachers to improve teachers' pedagogical content knowledge for teaching about scientific inquiry.

Strand 9: Reflective Practice
Poster Session A
3:15pm – 4:15pm, Riverside East

A97. Finding Ways to Contribute: Helping Undergraduate Students Realize Their Agency in Learning Physics
Sanaz Farhangi, New York University
ABSTRACT:
Undergraduate students usually do not play an agentive role in large science lectures. This paper explores student agency based on transformative activist stance theory, conceptualizing agency as the instances of contributing to the continuous flow of human activities. I argue that using this lens we can identify the ways students use their agency as well as helping them realize how agentive they can be. I used cultural-historical activity theory (CHAT) and Engeström's "Change lab" to facilitate the students' understanding of how they can change physics learning practices in an introductory physics course toward what they find relevant. Analysis of the focus group conversations and students' individual interviews show that the "change lab" conversations and tools opened a way for students to negotiate different meanings, find new positions and understand how they

can use their resources in a new light. I suggest that the use of this method of conversation as an integral part of an introductory physics course can lead to a change in students' engagement with science.

A99. Reflective Practices and Challenges in Being a Teacher-researcher
Konstantinos Alexakos, Brooklyn College-CUNY
ABSTRACT:
Framed by hermeneutic phenomenology, this presentation will explore the theory and practice of doing reflexive, ethical, and responsive social inquiry research as a teacher-researcher. Discussion will include methodologies, methods of data collection and analysis, issues of power, ethics, challenges and conflicts that emerge during such reflective practices as teacher-researchers.

Strand 10: Curriculum, Evaluation, and Assessment
Poster Session A
3:15pm – 4:15pm, Riverside East

A101. Designing Scoring Rubrics that Address Crosscutting Concepts in Science
Kevin W. McElhaney, SRI International
Angela H. DeBarger, SRI International
Cynthia M. D'Angelo, SRI International
Christopher J. Harris, SRI International
Kavita L. Seeratan, SRI International
Tina M. Stanford, SRI International
ABSTRACT:
The Framework for K-12 Science Education (NRC, 2012) identifies seven crosscutting concepts (CCCs) responding to concerns that K-12 science instruction lacks coherence across disciplines. Because the Next Generation Science Standards (NGSS) place the CCCs on equal footing with disciplinary core ideas and science practices, assessments are needed that measure student proficiency on CCCs concurrently with disciplinary core ideas and science practices. We describe an approach for incorporating CCCs into rubrics for assessments that also address content and practices, focusing specifically on the CCC "patterns." Our approach consists of four steps: (1) unpacking the CCC patterns by identifying pattern types and describing a high level of student performance; (2) developing a construct map describing levels of sophistication about patterns; (3) identifying specific connections among patterns, disciplinary concepts, and scientific practices for an assessment item; and (4) generating an item rubric. To illustrate the approach, we provide two examples addressing different disciplinary concepts and scientific practices, summarize the range of student responses on a pilot test of one item, and discuss a student example. This work promotes more consistent measures of student knowledge across disciplinary boundaries and has particular implications for longitudinal science assessment and developing coherent curriculum materials.

A103. Justifying Predictions: Connecting Use of Educative Curriculum Materials to Students' Engagement in Science Practices
Anna Maria Arias, University of Michigan
John-Carlos Marino, University of Michigan
Elizabeth A. Davis, University of Michigan
P. Sean Smith, Horizon Research, Inc.
Annemarie S. Palincsar, University of Michigan
ABSTRACT:

Scientific argumentation, a science practice emphasized in new education reforms, involves the justification of an explanation, model, or prediction. Despite evidence that children can engage in this practice, scientific argumentation is not typical in elementary classrooms. The authors proposed that justification of predictions could serve as an entrance point for scientific argumentation in elementary grades and developed a set of educative curriculum materials for two science units. The educative curriculum materials supported teachers in integrating science content with practice, including justifying predictions of scientific phenomena. As part of a large-scale, quasi-experimental study with two conditions: teachers with educative curriculum materials and teachers with the original curriculum materials, this study aimed to characterize differences in students' written predictions with justification across condition, discipline, and classrooms. Analyses showed improvement in the accuracy of students' claims after completing the unit in both conditions from pre-assessment to post-assessment. In the treatment condition where teachers had the educative features in the curriculum materials, the students' responses showed a significant increase in the presence of justification from the pre-assessment to the post-assessment; however, the comparison condition did not show these changes. These findings have implications for curriculum developers and teacher education.

A105. Development of an Instrument to Measure Teachers' Perceptions of Nanotechnology Teaching and Professional Development

Kuohua Wang, National Changhua University of Education
Shu-Fen Lin, National Changhua University of Education
Jun-Yi Chen, National Chiayi University
Kun-Yi Shih, National Changhua University of Education
Huey-Por Chang, Open University of Kaohsiung

ABSTRACT:
Nanotechnology is an emerging science and its interdisciplinary characteristic may have potential to implement STEM curriculum. To be able to successfully implement nanotechnology education, teacher quality has become a very important factor. In this study, we report on a process of developing an instrument to assess science teachers' self-understanding of teaching nanotechnology and needs of professional development. The instrument for the study is the "Teachers' Perceptions of Nanotechnology Teaching Scale (TPONTS)." The TPONTS included 45 Likert-scale items that can be grouped into six subscales: Intention of professional development for nanotechnology teaching, Perceptions of school support for nanotechnology teaching, Understanding of teaching strategies for nanotechnology teaching, Understanding of content knowledge in nanotechnology, Understanding of student learning of nanotechnology, and Understanding of integrating web resources into nanotechnology teaching. The instrument was administered to 409 secondary school science teachers in Taiwan, including 194 senior high school science teachers and 215 junior high school science teachers, for the purpose of conducting item and factor analyses. Results indicate that the TPONTS demonstrate validated factor structure, acceptable reliability, and good convergent validity.

A107. Clicker Score Trajectories and Concept Inventory Scores as Predictors of Student Success in Science Courses

Un Jung Lee, Stony Brook University
Gena C. Sbeglia, Stony Brook University
Minsu Ha, Kangwon National University
Stephen J Finch, Stony Brook University
Ross H. Nehm, SUNY Stony Brook

ABSTRACT:
Increasing the retention of STEM (science, technology, engineering, and mathematics) majors has recently emerged as a national priority in undergraduate education. Although the reasons why students switch from STEM majors are numerous, poor performance in large introductory science and math courses is one significant

factor. Consequently, early detection of struggling students is an important issue in STEM education. Our study explores the use of trajectory analyses of clicker scores as an approach for determining the time point at which robust predictions of student success can first be determined. These results are compared to the predictive power of traditional pre-course diagnostic assessment (i.e., concept inventory) scores. Our analyses revealed that diagnostic tests explained 29% of the variation in final grades. Adding all clicker scores increased explained variation to 56%. The average of the first four weeks of clicker scores predicted a satisfactory or unsatisfactory final course grade for 67% of the students. The trajectory analysis identified three distinct clicker performance patterns and their corresponding Bayesian Posterior Probabilities (BPPs) that were significant predictors of final course grade. Our analyses suggest that trajectory analyses of clicker scores are a potentially valuable tool for identifying at-risk students in large, introductory classes.

A109. A Case Study in the Evaluation of Alignment to NGSS using the EQuIP Rubric

Bernard J. Koch, AAAS/Project 2061
Sarah J. Glassman, George Mason University
George E. De Boer, AAAS/Project 2061
Jo Ellen Roseman, AAAS/Project 2061

ABSTRACT:
The conceptual shifts recommended by the Next Generation Science Standards have created an immediate need for the re-alignment of published curricula and the development of new compliant curricular materials. To facilitate this process, Achieve recently released the EQuIP rubric to aide teachers and curriculum developers in evaluating the alignment of curricular materials to NGSS. In this case study, we apply the EQuIP criteria for alignment to a set of online middle school earth science activities currently under development. Our experience using EQuIP suggests that the rubric is already quite helpful in informing users about NGSS's expectations for alignment. The analysis helped us to identify portions of the activities that do not align strongly and to generate ideas for additional aligned content. However, we feel developers may need additional instructional support to apply EQuIP's alignment criteria in a consistent and rigorous manner. Based on our experiences, we provide several suggestions to improve language, instructions, and organization within the EQuIP alignment column. We incorporate these suggestions into a form that guides users through an explicitly evidence-based evaluation of materials against EQuIP's criteria.

A111. A Discipline-Based Framework for the Force Concept to Inform Learning Progressions Research and Development

Irene Neumann, Leibniz-Institute
Daniel Laumann, Westfaelische Wilhelms-Universitaet Muenster
Gavin W. Fulmer, National Institute of Education
Ling L. Liang, La Salle University

ABSTRACT:
Research on learning progressions (LPs) has been of increasing interest to the science education research community over the past few years. With respect to the physics concept of force, a LP has already been developed and validated (Alonzo & Steedle, 2009); yet this LP focuses only on force and related motion in unidimensional settings. In order to describe students' learning about the force concept as a whole, other aspects of force need to be considered in LP research. Here we report about our efforts to derive a comprehensive picture of the concept of force. We reviewed common physics textbooks – as used on university level – to identify aspects of the force concept from a disciplinary perspective. Based on this review, we present a discipline-based framework of the force concept, that may be used as a guide to develop further LPs and to successively describe students' learning of the core idea of force as a whole.

A113. Validation of New Biology Instruments that Assess Three Aspects of Science Proficiency

Anna M. Strimaitis, Florida State University
Patrick J. Enderle, Florida State University
Jonathon Grooms, Florida State University
Victor D. Sampson, Florida State University
ABSTRACT:
This proposal describes the validation of three new assessments to measure students' scientific proficiency in high school biology. The biology content assessment measures student ability to know, use, and interpret scientific explanations. The biology writing assessment measures student ability to generate and evaluate scientific explanations and arguments. The biology performance task assesses student ability to participate in the practices and discourse of science. These three new assessments satisfied content, construct, and translational validity. They were determined to be reliable by calculating the inter-rater reliability using the intra-class correlation coefficient (ICC). Finally, the assessments were tested for and satisfied concurrent validity and discriminant validity. Multifaceted constructs such as science proficiency require a variety of tools to assess students' knowledge and abilities related to science. The three new assessments described in this proposal offer valid and reliable measures of students' science proficiency and can be used to assess gains in science proficiency over time and across instructional contexts.

A115. A Design Framework on Assessing Modeling Practices
Ji Shen, University of Miami
Charles Xie, Concord Consortium
Bahadir Namdar, Recep Tayyip Erdogan University
ABSTRACT:
Modeling is one of the eight core scientific and engineering practices mandated by the Next Generation of Science Standards (NGSS Lead States, 2013; NRC, 2012). It refers to the actions and reasoning processes with scientific models through which students learn and apply content knowledge and practical skills. Modeling practices encompass many complex cognitive processes and scientific aspects and are therefore difficult to assess. In this paper, we propose a theoretical framework that can guide the assessment of modeling practices. In the framework, a modeler's profile includes meta-modeling knowledge, modeling practices, and models created by students. Furthermore, the assessment of modeling practices is built on two epistemic dimensions of the modeling practices construct: the internal composition of a model and the external mapping to real-world phenomena. A set of qualitative and quantitative indicators of observable modeling practices are proposed based on this two-dimensional construct.

A117. Science and Engineering Practices Coverage in K-12 Engineering Curricula
Sonia A. Bendjemil, University of Virginia
Vivien M. Chabalengula, University of Virginia
Frackson Mumba, University of Virginia
ABSTRACT:
This study investigated the coverage status of science and engineering practices in K-12 engineering programs. Nine programs that are widely used in the United States involving two at elementary level, five at middle school, and two at high school level were analyzed via document content analysis method using the K-12 science education framework. Results revealed that developing and using model, and planning and carrying out investigations were highly covered practices; analyzing and interpreting data, constructing explanations and designing solutions, and obtaining, evaluating, and communicating information had medium coverage; whereas asking questions and defining problems, using mathematics and computational thinking, and engaging in argument from evidence were lowly covered. The implications of these results to science teaching and learning as well as to the development of next generation science materials are discussed. Key Words: coverage, science and engineering practices, K-12 engineering programs, K-12 science curricula

Strand 11: Cultural, Social, and Gender Issues
Poster Session A
3:15pm – 4:15pm, Riverside East

A119. Science Education in the Borderlands: An Examination of Science Readiness for Latina/o Learners in Texas
Jennifer K. LeBlanc, Texas A&M University
Dane Bozeman, Texas A & M University
Carol L. Stuessy, Texas A&M University
Abiola Farinde
Kaitlin Stone, College Station I. S. D.
ABSTRACT:
In this paper we examine the state of science and college readiness in one "borderland" state (Texas). We specifically examine school level indicators to identify the frequency of highly successful schools that serve predominantly Latina/o learners. Then we discuss the current state of literature regarding Latina/o leaners in secondary science education as it intersects the How People Learn (Bransford, Brown, and Cocking, 2000). Based on the results from our research we confirm that opportunities to learn science in the borderlands are not equitable. Additionally, we confirm that the literature regarding Latina/o learners in science education is sparse. Most surprisingly we find that the literature with regards to Latina/o learners in secondary science education and the intersection of the components of the How People Learn Framework is nonexistent.

A121. The Effect of Quorums in Biology, Chemistry, and Physics on Student Performance and Interest
Zahra Hazari, Florida International University
Geoff Potvin, Florida International University
Allison F. Godwin, Purdue University
Tyler Scott, Northwestern College
Leidy Klotz, Clemson University
ABSTRACT:
It has been hypothesized that sensing a quorum (critical mass) might impact students' persistence in Science, Technology, Engineering, and Mathematics (STEM). For example, female students who sense a quorum of females in a discipline, rather than feeling isolated, may be more likely to become engaged or persist in the subject. We tested the effect of sensing gender-based quorums (same gender science class members) and interest-based quorums (interest level of science class members) in high school biology, chemistry, and physics classes on career interests and performance in biology, chemistry, and physics. After controlling for preexisting differences between groups, students who experienced a same-gender quorum in any of the subjects were not significantly more likely to choose a career in the corresponding subject while students who experienced an interest-based quorum were significantly more likely to choose a corresponding career. The results indicate that high interest levels amongst peers within a science class may positively impact achievement and persistence towards related science careers.

A125. The Unbearable Lightness of School Science: A Mixed Methods Study of Three Different Gender-based High Schools in South Korea
EunJin Bang, Iowa State University
Yohan Hwang, Kyungpook National University
Sissy S. Wong, University of Houston
Inkyu Jeong, Sukji High School, South Korea
Youngjin Song, University of Northern Colorado

ABSTRACT:
This mixed methods study explores 1) science learning environments, 2) science learning experiences, and 3) career aspirations of the Korean students in the three different gender-based high schools. Through the lenses of gender equity and cultural border crossings, this study aims to reveal the backstage views of school science in the context of South Korea—notable in that this system has been consistently ranked among the very highest for its the international science assessment scores. Participants of the study included three principals and science teachers, 302 high school students from all-male, all-female, and co-educational schools. Data have been collected through four different sets of questionnaires, focus group interviews, and field notes. The initial findings indicate that the cultures of the all three schools and sciences overlap in a fairly similar manner (e.g. lecture style teaching combined with rote memorization learning). Due to the lack of a culturally diverse learning environment and the opportunity of being exposed to different ways of learning, hazardous transitions were detected that generated many "I Don't Know" students whose transitions to becoming potential scientists seemed less promising (Costa, 1995). Further discussions will be reported in terms of how to effectively establish better environments for all.

A129. Broadening Participation in the Biological Sciences: Understanding Recruitment Initiatives from Students' Perspective

Cheryl A. McLaughlin, University of Florida
Gil Nelson, Florida State University
Shari Ellis, Florida Museum of Natural History

ABSTRACT:
There is growing concern within the academic community about the number of women, underrepresented minorities, and persons with disabilities in STEM workforce. Furthermore, despite the numerous initiatives designed to redress race/ethnic disparities in STEM, reports have indicated that progress has been disturbingly slow and uneven across underrepresented groups. This poster paper showcases a multi-institutional recruitment initiative aimed at increasing the participation of underrepresented groups in the biological sciences. It explores, from the students' perspective, the value of this recruitment effort in influencing their decision to pursue graduate degrees and careers in the field of biology. A mixed methods approach was employed to obtain students' perspectives on ways in which the recruitment initiative contributed to their motivation for prolonged engagement in the biological sciences. Our findings suggest that recruitment initiatives, if designed with students' perspective in mind, have the potential to shape students' decisions to pursue further studies and career opportunities in the biological sciences.

A131. Tensions in the Enactment of Formative Assessment: A Case Study in a High-School Chemistry Classroom

Dante Cisterna, Pontifical Catholic University of Chile
Amelia Wenk Gotwals, Michigan State University

ABSTRACT:
This single case study characterizes the enactment of formative-assessment practices of Diane, a high-school chemistry teacher and science department chair, who participated in a professional development to learn about formative-assessment. By using cultural-historical activity theory (CHAT), this study focuses on the main tensions that emerged in Diane's classroom when enacting this new practice. The analysis of Diane's activity system showed that her enactment of formative assessment implied a tension between the purpose of the tools that were created in the professional development and her expectations about students' chemistry learning. Although in the professional development Diane demonstrated understanding of how formative assessment may serve to promote student learning, the way she enacted formative assessment was different from its intended purpose. In Diane's classroom activity system, for example, there were tensions between the classroom rules and in the division of labor and the outcome. Diane's instructional and assessment foci were targeted to prepare

students to perform successfully in college chemistry courses and in chemistry high-stakes assessments, but not necessarily to help students learn core chemistry ideas. This study discusses implications for better connecting formative-assessment professional development and classroom practice.

Strand 12: Educational Technology
Poster Session A
3:15pm – 4:15pm, Riverside East

A133. Individual Differences/Moderators of Science Content via 21st Century Skill Acquisition using Serious Educational Games
Kaylan B. Petrie, Washington State University
Richard L. Lamb, Washington State University
David B. Vallett, University of Nevada Las Vegas
Leonard Annetta, George Mason University
Rebecca Cheng, George Mason University
Marina Shapiro
Ben Matthews
ABSTRACT:
Attention and focus on P-12 STEM education has increased in recent years. Many efforts are underway to promote STEM course selection specifically in engineering and computer science across the nation. In the push to develop these programs and pathways to STEM career selection, educational researchers and curriculum developers often overlook student individual difference as contributing to content knowledge acquisition and development of critical skills as they develop curriculum and work with preservice teachers in the university setting. The purpose of this presentation is to examine the effectiveness of the use of SEGs in a 9-12 science classroom and examine underlying moderating variables of individual difference predicting increased outcomes related to 21st Century Skill acquisition and Science Content acquisition. Targeted subjects consist of 585 students enrolled full-time traditional high school science program at the grade 9-12 levels. Results of the mean comparison between the comparison and intervention groups illustrate a statistically significant difference between each group on the gain scores related to Science Content and 21st Century Skills with the intervention group scoring higher. Seeking to promote 21st Century Skill integration and science content acquisition in the science classroom though SEG play can provide disciplinary convergence through underlying cognitive attributes.

A135. A Potential Future in Education: The Application of Intelligent Systems in Teacher Education
Andy Cavagnetto, Washington State University
Richard Lamb, Washington State University
Brian French, Washington State University
Lijun Yin, Binghamton University
Olusola Adesope, Washington State University
Matthew Taylor, Washington State University
ABSTRACT:
A computer program passed the Turing test. To pass the Turing test a computer must convince at least 30% of human interlocutors that the machine is a human and not a machine. This amazing achievement foreshadows a future in education–artificial tutors that truly exhibit artificial intelligence in the form of intelligent systems as they interact with preservice teachers simulating students in realistic ways. Driver, Newton, and Osborne (2000) studied 34 secondary science lessons, documenting classroom interactions in 30-second intervals over each lesson. Across lessons, only two instances occurred in which a teacher engaged students in-group discussions.

Follow up interviews with teachers suggested that the teachers recognized the value of the discussions, but lacked tools and experience in engaging students in such forums. The intelligent systems provide a means to establish this experience in a virtual soft failure environment. Difficulties with group discussions are particularly evident when students are trying to make sense of observations from an investigation (Morge, 2005). The conclusion phase of inquiry investigations constitutes a clear point of convergence of the aforementioned four strands of proficiency (NRC, 2012). The lack of opportunity for student voice has also been uncovered by national surveys as well.

A137. Using Mobile Technologies to Facilitate Student-to-teacher Questioning in a Large Undergraduate Astronomy Course

Stephen R. Burgin, Old Dominion University
Helen Crompton, Old Dominion University
Kristen H. Gregory, Old Dominion University
Declan G. De Paor, Old Dominion University
Raleta Summers, Old Dominion University

ABSTRACT:

An investigation was conducted regarding the use of mobile technologies to foster student-generated questions asked in a large undergraduate astronomy course. The relative frequencies of the types of questions asked by students were analyzed. While all student questions were sent via SMS text messaging from hand-held devices, some were received by the professor on his cellphone and others were received via Google Glass. Additionally, the professor and the TAs of the course were interviewed regarding their perspectives of the use of these technologies to promote student questioning in this context. Findings revealed some limited differences between the text-to-phone questions and the text-to-Google Glass questions in terms of the levels of questions asked. In general, the professor and the TAs thought that using text messaging for students to ask questions provided a level of anonymity that encouraged the asking of questions which was valuable even if some were of a low level. Additionally, they felt that the use of Google Glass promoted more “real-time” questions that were likely of a higher level. Implications for undergraduate science education and the use of mobile technologies in this setting are discussed.

A139. Using a Computer Game to Introduce Scientific Explanations to Students

Robert C. Wallon, University of Illinois
Chandana Jasti, University of Illinois
Hillary Z. Lauren, University of Illinois
Barbara Hug, University of Illinois

ABSTRACT:

A Framework for K-12 Science Education specifies eight scientific practices in which students should engage to more effectively learn science. Two of the practices are “constructing explanations” and “engaging in argument from evidence” (NRC, 2012). These practices have been integrated into the Next Generation Science Standards, and as states adopt and enact these new standards more teachers will seek resources to align their curriculum. Recent research provides valuable insight into how the elements of teacher instruction, specific scaffolds, and digital environments can impact students’ development of scientific explanations. However, more research is needed to determine different and effective ways to engage students in the scientific practices.The purpose of this case study is to describe how a high school biology teacher introduced her students to writing scientific explanations through the context of a computer game about traumatic brain injury and associated curriculum materials. Teacher instruction and student artifact data from two consecutive years of enactment were collected, characterized, and compared. Our findings suggest scaffolds external to the computer game play an important role in helping students write high quality scientific explanations. Implications for curriculum development are also discussed.

A141. Using Mobile Apps to Support Scientific Practices in Middle School

Kelly M. Mills, University of Maryland
Uma Natarajan, University of Massachusetts, Boston
Diane Jass Ketelhut, University of Maryland

ABSTRACT:
Mobile technologies, when designed appropriately and used effectively, hold great potential for students to meaningfully engage in science practices, as identified in the Next Generation Science Standards (NGSS). This paper seeks to identify ways in which teachers can weave apps in instruction to promote science practices, as described in the NGSS standards. Thirty apps, currently available and suited for middle school students were analyzed for their potential to facilitate science practices. Suggestions for activities that will help teachers to include apps to help their students to think about and understand science practices are included. It is certainly possible that integrating these mobile apps will facilitate science learning by engaging students, explaining science concepts in multiple ways and making science practices easily accessible.

A143. Designing Cooperative Online Learning Tools for Middle School Science: Lessons Learned from Three Exploratory Studies

Fatima E. Terrazas Arellanes, University of Oregon
Alejandro J. Gallard, Georgia Southern University
Emily D. Walden, University of Oregon

ABSTRACT:
Education technology provides equitable access for all students to meet the Next Generation Science Standards (NGSS). Literacy barriers often cause English Language Learners (ELLs) and Students with Learning Disabilities (SWLD) to experience marginalization when learning science. This paper discusses the development process by Project COPELLS (Collaborative Online Projects for English Language Learner Students) of an online science curriculum, and the subsequent Project ESCOLAR (Etext Supports for Collaborative Online Learning and Academic Reading) in aligning the curriculum to the NGSS and providing online text supports. Iterative case and pilot studies (N = 212 students, 69% ELL) informed the curriculum' development. Curriculum refinements were made based on feedback from informants, including teachers, students, content experts, and observers. Results showed that by the last iteration, feasibility and usability was established and students improved from pre- to posttest on science content assessments. Recommendations for using an iterative process in developing curricula, utilizing education technology to provide equitable access to all students, and the need for curriculum aligned with the NGSS are included.

A145. Pre-service Teachers' Understanding of Design Technology: Modeling Oriented Assessment(MOA) for Enhancing the Feasibility of STEM

Young Ae Kim, Department of Mathematics & Science Education, University of Georgia
Deborah J. Tippins, The University of Georgia

ABSTRACT:
The purpose of this case study is to analyze secondary pre-service teachers' understanding of modeling practices and modeling oriented assessment (MOA) in STEM contexts through designing a hand model activity. This study was conducted with two groups of secondary pre-service teachers enrolled in a required teaching and learning methods course. In the design task "Crazy Candy Factory" participants were provided with a set of consumable materials and were challenged to design a model hand and use their models to pick up candies of various sizes and shapes. Audio- and video-recordings, post-reflections, and a focus group discussion with all participants were conducted. Several findings were suggested in this study. Secondary pre-service teachers drew from diverse interdisciplinary knowledge (e.g., physics, anatomy, and geometry) and used different approaches in the design process. Also, pre-service teachers understand that modeling practices foster students'

engagement, creativity and collaboration. Furthermore, most pre-service teachers see the possibility of using design tasks with modeling practices in their future classrooms. This paper highlights how the modeling practices are connected with STEM integrated approaches in science curriculum. In addition, modeling practices and modeling oriented assessment (MOA) enable more extensive STEM education in science classrooms.

Strand 13: History, Philosophy, and Sociology of Science

Poster Session A

3:15pm – 4:15pm, Riverside East

A147. The Estonian Stakeholders' Views about the Level of Students' Scientific Literacy and the Support of New Estonian Competence-based Science Education Curriculum

Anne Laius, University of Tartu
Aveliis Post
Miia Rannikmae, University of Tartu

ABSTRACT:

This research solicits views about the goals of science education from a wide range of stakeholders within the science education community (students, pre-service teachers and science educators) and also employees from private and public sectors. Its goal is to increase the confidence levels of teachers in meeting the goals of the new competence-based curriculum introduced through relevant in service programmes and also to compare students' needs, expressed through stakeholder expectations, with the current situation in science education. This research used a modified Delphi method with 111 participants in the 1st round and 172 participants in a 2nd round of Delphi study. The results revealed significant gaps between the expectations of all investigated groups and the actual realisation of levels of obtained competences by students at school. The smallest gaps between importance and realisation of useful competences for scientific literacy of the future workforce occurred with the secondary school students. All other groups differed significantly, but the different groups of teachers follow a similar pattern with minor differences, valuing academic knowledge the most. The scientists were most sceptical about the present state of science education at school and employers expected good personal qualities in future employees. Keywords: stakeholders, science education, competence-based curriculum

A149. Improving Students' Understanding of Nature of Science through Reflective-contextualized Socioscientific Issues Instruction

Yoonsook Chung, Ewha Womans University
Sung-Won Kim, Ewha Womans University

ABSTRACT:

The guiding research question was as below: 1) to what extent students develop their understanding of NOS? 2) To what extent SSI contexts contributed to promoting students' understanding NOS? A total of seventy one students (11th graders) participated in this research. The SSI program was developed to cover the issues of genetically modified organism, global climate change, and nuclear energy. Each issues required 4 to 6 class periods to complete. The overall process of SSI program was as follows. SSI program consists of three steps: Introduction, explicit-reflective Nature of Science learning, and decision making. The students were asked to evaluated claims of each article, analyze the evidences, or examine the credibility. Such request was intended to encourage students to reflect their own view on NOS and to make connections between SSI and NOS. The teacher encouraged students to confront their core beliefs on science during all the classes. Data were collected by pre and post VNOS-C test, interview, activity sheets. The researcher developed rubric inductively to evaluated students' answers according to cross case analysis. Students' NOS conceptions were compared by

Wilcoxon signed rank test and chi square test. As a result of this program, students showed moderately improvement in their understanding of NOS. Students view on the empirical nature of science, tentativeness of science, and social-cultural embededded were significantly improved. The students were able to apply NOS conception from one SSI context to the other SSI context even though they could not transfer NOS concept from general context to SSI context.

Strand 14: Environmental Education
Poster Session A
3:15pm – 4:15pm, Riverside East

A151. Testing a Curriculum Designed to Build Students' Understanding of Action at an Attentional Distance
Maleka D. Gramling, Harvard University
Daniel E Oh, Harvard University
Kasia Derbiszewska, Harvard University
Lynneth Solis, Harvard University
Tina Grotzer, Harvard University
ABSTRACT:
The newly adopted Next Generation Science Standards (Achieve, 2013) include Cause and Effect as one of "seven cross-cutting concepts. Causal understanding in environmental contexts is impacted by action at a distance—that causes and effects can be separated in space and time. The concept of action at an attentional distance refers to special cases where causes and effects are in different attentional frames; this makes the likelihood that the causal connection will be detected through co-variation remote. Spatial discontinuity between causes and effects is a feature of many scientific concepts, particularly those in the environmental and ecological sciences, for instance, from protecting watersheds to impacts on species such as polar bears in the Arctic. This poster reports on a study of a curricular intervention designed to help middle school students understand and attend to action at an attentional distance. Following a pilot test, the curriculum was revised and tested in 14 classes (n= 325) of seven teachers. Promising shifts were found in students' assessment of the importance of considering distal factors. This poster considers how students' thinking changed across open-ended and a Likert Style inventory as well as how teachers enacted the curriculum.

A153. Investigating Student Reasoning about Agency in Ecosystems Science
Megan M. Powell, Harvard University
Tina Grotzer, Harvard University
Amy M. Kamarainen, New York Hall of Science
Shari Jackson Metcalf, Harvard University
ABSTRACT:
Students' understanding of agency has implications for science education, especially for phenomena in which the causal mechanisms are complex or non-obvious. Research has investigated how students reason about agency and intentionality in a number of scientific domains, including the existence of natural artifacts (e.g. Kelemen, 1999) and the process of natural selection (e.g., Evans, 2000). In this study, we investigate seventh grade students' (n = 314) application of agency to an ecological scenario (the death of fish in a local pond) through analysis of their responses to an open-ended writing prompt. Emergent coding explores students' tendencies to attribute outcomes to agentive causes as well as their assumptions about the intentionality of the agents. Findings suggest that students were more likely to generate agentive than non-agentive explanations for the death of the fish. Students were also most likely to assume that the agents' actions were intentional but the ultimate outcome (the death of the fish) was unintentional.

A155. Merging Digital Storytelling with Science and Environmental Education: A Longitudinal Case Study with Promising Results

Brian J. Plankis, Indiana University Purdue University Indianapolis
Ashley Poloha, Pasadena Memorial High School

ABSTRACT:
This presentation will cover a four year longitudinal case study that examined combining the powerful Investigating and Evaluating Environmental Issues and Actions (IEEIA) framework (Marcinkowski, 2001) with the motivating and reflective process of digital storytelling (Lambert, 2002) with over 200 students in Texas, USA. The presentation will focus on the adjustments that were made to utilize the best pieces of the IEEIA framework, adjust to the characteristics of the particular students, what technology training was needed, and a demonstration of the final digital videos the student teams created about their chosen environmental issues. A key focus of the presentation will be on improving the project framework that was developed as it could easily be adapted to other science education and environmental education topics. The authors would like to engage the audience in a methodology discussion with the aim of improving the rigor of this process and assessment of the videos for science content and environmental literacy. Discussion of results will focus on the promising and strong qualitative elements of this project framework and the authors' suggestions for making the evaluation of the entire process more rigorous. Audience interaction will be highly encouraged.

A157. Educating the Next Generation of Elementary Teachers: Fostering Preservice Teachers' Pro-environmental Engagement

Lyn Carter, Australian Catholic University
Jenny L. Martin, Australian Catholic University

ABSTRACT:
This paper contributes to theory for researching applied dimensions of scientific literacy and to understanding ways to promote preservice teachers' sense of responsibility for education for sustainability (EfS). EfS is one of the most effective means we have of bringing about the changes needed for the transition to sustainability. However, previous research suggests knowledge is not the most import and factor in the development of applied dimensions of scientific literacy, such as pro-environmental engagement. We present findings from our investigation of pre-service teachers' development as scientifically literate citizens to show how their pro-environmental engagement is limited and promoted through existing discourses, and to argue that individualistic conceptions of the mind and knowledge are inadequate for researching pro-environmental engagement. Our research shows that as only a small percentage of preservice teachers seem to be able to synthesis existing discourses and developing critical perspectives that "conservationist/resourcist" approaches to environmental education (Sauvé, 2005) in preservice teacher education may be less useful. We recommend the exploration of "socially critical" and/or "values-centred" (Sauvé, 2005) approaches to environmental education, and science education in general, as a way forward for the development of applied dimensions of scientific literacy in teacher education.

Strand 15: Policy
Poster Session A
3:15pm – 4:15pm, Riverside East

A159. Science Teacher Certification, Access to Science, and Student Learning in an Urban Setting

Michelle R. Turner-Edwards, Stony Brook University
Angela M. Kelly, Stony Brook University
Keith Sheppard, Stony Brook University

ABSTRACT:

Inequities in science education have been a persistent problem in U.S. schools. Students from low-income areas often have not had equal access to rigorous science coursework and qualified science teachers, having far greater numbers of inexperienced and uncertified teachers than their affluent peers. The context for this study is a high needs borough in New York State, whose public schools have been considered the most segregated in the country both in terms of racial composition and socioeconomic status. The theoretical framework for this study is based upon Darling-Hammond's work in teacher preparation, which argued that variations in teacher credentials accounted for greater differences in student achievement on nationally administered exams than did either ethnicity of socioeconomic factors. Publicly available databases were accessed to determine science teacher certification status, high school science course availability, and science achievement for students in Bronx County. The data revealed that Bronx students had disproportionate numbers of unqualified and inexperienced science teachers, their science achievement was weak, and they often did not have access to advanced science coursework. This quantitative analysis illuminates the complex relationship among race, socioeconomic status, science teacher qualification, access to advanced science, and student science achievement.

A161. A Case of High School Earth and Space Science Education in the Great Plains

Elizabeth B. Lewis, University of Nebraska-Lincoln
Jia Lu, University of Nebraska-Lincoln
Megan Van Alstine, University of Nebraska-Lincoln

ABSTRACT:

While U.S. high school students' access to Earth and space science (ESS) varies widely from state to state, nationally ESS content is the most neglected area of science education. States are in the process of formally adopting the NGSS. However, the authors of the standards rarely address the classroom-level challenge with which states, school districts, and teachers must grapple in order to enact science lessons that reflect the distinctive features of ESS concepts and show that their students are meeting 9-12 learning objectives. This study of one Great Plains state asks "How do school districts provide ESS education at the high school level?" In an analysis of the state database over a 6-year period there were 624 secondary science endorsements, with only 2.6% in ESS. Thus, most teachers teaching ESS are doing so out-of-field. ESS is either a stand-alone course in a semester or year-long format, or ESS concepts are integrated with other science classes. In larger districts there are more resources available and curriculum specialists devoted to supporting science teachers. In small rural schools where there may only be one science teacher at one high school, science teachers are especially challenged to teach all areas of science equally well.

A163. Taiwanese Policymakers' and Science Teachers' Perspectives on Science Education Reform in Confucian Learning Cultures

Ying Syuan Huang, McGill University
Anila Asghar, McGill University

ABSTRACT:

This qualitative inquiry seeks to investigate secondary science teachers' and policymakers' perspectives on science education reform in Taiwan. It unravels the challenges involved in implementing constructivist pedagogical approaches in Confucian learning cultures. Data from multiple sources including policy documents, curriculum guides, interviews with teachers and policymakers, as well as teachers' reflective journals were used to understand various discourses around the reform. Data were analyzed using various analytical tools, such as concept mapping, thematic analysis and the constant comparative method. These analyses revealed diverse perspectives on the complex interactions between Confucian learning traditions and reform-based practices. Notably, teachers' cultural beliefs about teaching conflicted with inquiry-based learning approaches leading to intense internal strife; this seemed to have important implications for teachers' professional identity. Theory of identity conflicts and construction were employed to understand teachers' struggles and challenges while

wrestling with competing cultural and reform-based pedagogical approaches. This work has important implications for current and future education reform initiatives in Taiwan and other Eastern cultures. In particular, this research highlights the importance of considering teachers' cultural values and epistemological beliefs while planning and implementing educational reforms to support teachers in the change process.

Poster Session B
4:15pm – 5:15pm, Riverside East

Strand 1: Science Learning, Understanding and Conceptual Change
Poster Session B
4:15pm – 5:15pm, Riverside East

B2. Students' Self-efficacy in Possessing Perspectives and Competences for Developing Scientific Literacy for Success in Future Careers
Kerti Ait, Tartu University
Jack Holbrook, Tartu University
Miia Rannikmäe, Tartu University
ABSTRACT:
The emerging views of scientific literacy in the 21st century have led to a new scientific literacy model embracing five key components: skills, content knowledge, metacognition, nature of science and values. One determining factor that can delay or advance the development of scientific literacy is seen as the students' self-efficacy. As such, this research is geared towards measuring students' self-efficacy associated with the aforementioned dimensions of scientific literacy and exploring the degree to which students value the importance of the different components so as to be successful in their future career. Results revealed that students' self-efficacy associated with each component of the scientific literacy model we are shown to be higher than average. We also found that all components of the model showed statistically significant correlations with each other, except for science as a human endeavour. The results showed that students feel themselves most confident in valuing the world in which they live and they feel themselves less confident in content knowledge.

B4. 5th Grade Korean Students' Decision-making on Animal Testing: Patterns of Responses to Anomalous Data
Hwayeon Lee, Korea National University of Education
Nam-Hwa Kang, Korea National University of Education
ABSTRACT:
5th grade students (12 males) in South Korea participated in this study. There were three students with learning disability and two students identified as academically gifted. The students answered survey questions in the beginning, participated in argumentation, and were given counterevidence to review their initial positions. Written responses and video- and audio recording data were collected, transcribed, and analyzed. Some students demonstrated unconditional acceptance or rejection of counterevidence while others presented various reasons for their responses to counterevidence. Unconditional acceptances or rejections demonstrated a couple of issues in teaching with socioscientific issues. Also, the patterns of students' reactions to counterevidence showed that they used different validity criteria for evidence. These issues were discussed in relation to classroom teaching with SSI.

B6. Community College Students Making Sense of Cosmology Visualizations
Zoe E. Buck, University Of California Santa Cruz
ABSTRACT:

In this study I look at how dynamic cosmology visualizations are used by small groups of community college students to make sense of science content. I present evidence that visualizations can support cosmological sense-making, which I define as engaging in object-oriented learning activity mediated by concepts and practices associated with cosmological literacy as determined in consultation with cosmologists. The visualizations allowed the students, many of whom were from non-dominant linguistic backgrounds, to grapple directly with cosmology content while practicing the language of science. This process was facilitated by a drawing activity that served as an improvable object, encouraging cosmological sense-making. The students used hybrid language and analogy to make sense of the visualization, describing the patterns and dynamics of the system even when they did not articulate scientific vocabulary like "gravity." This could be due in part to the potential for visualizations to present complex information without necessitating complex vocabulary. In light of these findings, I argue that carefully incorporating visualizations into learning environments can improve access to cosmology content for learners, particularly those who come from cultural or linguistically diverse backgrounds.

B8. Meaningful Conceptual Learning in Engineering-Oriented Teacher Professional Development: A Conceptual Framework

Baki Cavlazoglu, Texas A&M University

ABSTRACT:

As recent calls emphasize increasing science teachers' engineering content knowledge and the critical role of professional development on engineering content for science teachers, effective Engineering-Oriented Teacher Professional Development (EOTPD) to enhance science teachers' engineering content knowledge has become crucial, but currently there is no conceptual framework describing effective conceptual understanding of engineering content in EOTPDs. Therefore, a new conceptual framework for science teachers' conceptual understanding of engineering content knowledge in EOTPDs is indispensible. This study aims reflecting related literature on important components of effective EOTPDs and purposing a new conceptual framework for effective EOTPDs. The conceptual framework of this study, meaningful conceptual learning (MCL), indicates that to enhance and sustain change in science teachers' conceptual understanding of engineering content knowledge, an effective design of EOTPD should include cognitive scaffolds, collaboration, argumentation discourse, and authentic assessment components.

Strand 2: Science Learning: Contexts, Characteristics and Interactions

Poster Session B

4:15pm – 5:15pm, Riverside East

B10. The Quality of Online Graduate Science Courses: Voices from Students and Instructors

Sanghee Choi, University of North Georgia
April Nelms, University of North Georgia
Chantelle A. Renaud-Grant, University of North Georgia

ABSTRACT:

The purpose of this study is twofold: to identify factors and common challenges experienced by students enrolled in summer, online graduate science courses and to determine factors and challenges faced by instructors. This study also looks at the factors that helped students to stay on track and complete the course and how reflection has helped online instructors and the strategies they employed to improve their courses. Participants were 103 inservice middle grade teachers who enrolled in summer graduate online courses in 2013 and 2014. Data were collected from graduate online courses that included four sections of Physical Science courses and two sections of Mathematics and Science Curriculum and Assessment courses. End-of-course surveys with graduate students and end-of-course interviews with course instructors and their journals

throughout the study were collected. Results suggested that adding more synchronous tools such as chat rooms and virtual conference meetings would accommodate individual needs and utilizing a variety of virtual labs improved student engagements and enhanced students' scientific exploration and inquiries. Lastly, over two years, a trend has emerged indicating the instructors' flexibility and personal touches are most important factors that create a more engaging and meaningful learning environment to increase the effectiveness of online learning.

B12. Exploring the Relation between Learners' Beliefs in Science Reading and the Science Text Understanding
Fang-Ying Yang, National Taiwan Normal University
Cheng-Chieh Chang, National Taiwan Ocean University
ABSTRACT:
This study explored the relation between learners' beliefs in science reading and their understanding of the science text. More than 300 10th graders participated in the initial development of the Beliefs in Science Reading Inventory (BSRI) and another 97 students were involved to verify BSRI by the confirmatory factory analysis. The statistical analysis supported that the BSRI is a proper tool to detect learners' beliefs in science reading. To find the relation between reader beliefs and text understanding, a new group of 65 9th-grade students were invited to take part in a reading task. After reading, participants were asked to interpret what they had learned from the reading material. Students' written responses were then examined by the content analysis. Descriptive, correlation and regression analyses were conducted to find associations between learners' beliefs in science reading and the science text understanding. The study found that interpretations of the science text were interacting with personal beliefs in science reading. In particular, when readers believed more of constructing meanings based on personal goals, they generated more complicated interpretations about the reading material. Meanwhile, it was also found that beliefs in accepting authors' intended meanings were related to readers' reactions on the text.

B14. Empirical-based Model to Explain the Impact of Science Classes on Students' Career Choice
Nina Bertels, Freie Universitaet Berlin
Claus Bolte, Freie Universitaet Berlin
ABSTRACT:
We examined in which way chemistry lessons influence students´ intended career choice. Based on different theoretical approaches we are interested in answering the following question: Are the variables motivational learning environment, developmental tasks, self-to-prototype matching and self-concept connected to the career choice? For this purpose we developed a questionnaire which includes the variables motivational learning environment, self concept, self-image and prototypes and developmental tasks. The questionnaire was given to students of German schools (Hauptschule) and trainees of the chemical industry. A regression analysis showed that the variables partly influence the choice of career.

B16. Characterizing Changes to Students' Motivation in Science in Schools That Serve Low SES Communities
Israel Touitou, Weizmann Institute of Science
David L. Fortus, Weizmann Institute of Science
ABSTRACT:
Motivation plays a central role in the fruitfulness of students' tenure at school. Students that have adopted mastery achievement goals are more likely to be persistent, challenge-oriented, self-regulated, and have high self-efficacy as learners. Research has demonstrated that students' mastery goals orientation typically declines towards the end of elementary school and during middle school. In schools serving low socio-economic populations, this problem is compounded by the lack of resources and general issues with students' self-efficacy and stereotypical mental images of one's self. The goal of this study was to characterize the environmental factors that influence the motivation of students from low SES backgrounds to engage in science learning, in

and out of school. Results show that students from low SES backgrounds perceive goal theory constructs differently than student from higher social-economic backgrounds. We were able to show that apparently it is the differences between the students' personal levels of mastery orientation and their perceived mastery emphases of the environmental that lead to changes in their personal mastery orientation. Building upon these results, we are hoping to better understand how to enhance the motivation for science of students in low SES schools.

B18. Reading Problems Faced by Students Studying Science in a Foreign Language

Nada Radwan, King's College London
Saouma B. BouJaoude, American University of Beirut

ABSTRACT:
Students who are native and non-native speakers of English face challenges and difficulties when they read to learn science from their textbooks. These difficulties include problems with scientific vocabulary (technical words) and everyday words used in a scientific context (non-technical words). Non-native speakers of English are at an additional disadvantage since they need to learn two languages concurrently, the second language (English) and the language of science. The purpose of this study was to investigate the problems that elementary level students who are non-native speakers of English face while reading their science textbooks. Participants in this study were 196 grade six students from elementary schools in Middle East Country. Participants took a multiple choice test and a grouping worksheet which examined their comprehension of technical and non-technical words while 20 students were randomly selected for follow up interviews. Results indicate that students face serious difficulties with the comprehension of most technical and non-technical words. For example, students found technical words with multiple meanings challenging and resorted to everyday definition of these words. Moreover, participants assigned either opposite meanings or imprecise meanings and chose look-alike and sound-alike words when responding to the items of the test on non-technical words.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Poster Session B
4:15pm – 5:15pm, Riverside East

B20. A Neuroscience Approach to Teaching K-1 Students about the Senses

Alana Newell, Baylor College of Medicine
Barbara Tharp, Baylor College of Medicine
Nancy Moreno, Baylor College of Medicine

ABSTRACT:
Students as young as kindergarten are expected to begin to make observations and construct evidence-based explanations based on the world around them, but there are very few science lessons that fulfill this need. The Brain and Senses set of activities helps students understand that the five senses are all connected to their brains, and lay the groundwork for the higher level science content they will encounter later in their K-12 careers. Outcomes from pre- and posttests administered to 559 PK-2nd grade students who participated in the field testing of the materials indicate that even students as young as kindergarten are able to grasp basic neuroscience concepts, and differ significantly in this knowledge at posttest from 620 of their peers who did not participate in the activities. These results suggest that complex, up-to-date science concepts effectively can be integrated with early elementary curricula in ways that are understandable to students and provide a solid foundation for future science coursework.

B22. The Role of Epistemic Orientation and Pedagogical Content Knowledge in the Practice of Teaching Science

Jee Kyung Suh, University of Iowa
Soonhye Park, University of Iowa

ABSTRACT:
The primary purpose of this study was to examine how elementary teachers' Epistemic Orientation toward Teaching Science (EOTS) and Pedagogical Content Knowledge (PCK) play collaborative role in instructional decision-making process for teaching science through scientific practice. A multiple-case study was utilized to describe the complex phenomena that occur in the decision making process. Three experienced elementary teachers were recruited as participants. This study empirically explored how teachers' sets of beliefs about knowledge, learning, and teaching and PCK provide resources for teachers to address many facets of instructional practices that are embodied in learning environment. This will provide insights into the ways teachers shape their instructional practices to foster student learning through scientific practice.

B24. Translating Elementary STEM Integration into Classroom Practice

Tamara J. Moore, Purdue University

ABSTRACT:
Despite the recent emphasis on improving STEM education and increasing the teaching of STEM disciplines in a more connected manner, there remains confusion over what constitutes STEM and STEM integration (NRC, 2009; 2014). This study addresses the need for more research to explore the translation of STEM integration from national policy and research into classroom practice by identifying and characterizing current approaches to STEM integration that are being implemented in elementary classrooms. A multiple case study was employed due to the fact that it allowed for the in-depth investigation of teacher implementation of STEM integration in a classroom setting. These results shed light on existing approaches that have been used by elementary teachers to integrate STEM into their classroom as well as provide information regarding what lessons can be learned from some of these early adopters in regards to the implementation of integrated STEM curriculum in elementary classrooms.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Poster Session B
4:15pm – 5:15pm, Riverside East

B28. How a Teacher's Personal Epistemology of Science Influences the Science Practice Students Learn

David Stroupe, Michigan State University

ABSTRACT:
This study investigated the role of a teacher’s personal epistemology of science – defined as their vision of the conceptual, epistemic, social, and material dimensions of science practice – as a primary influence on the ways in which they provided students with opportunities to learn particular forms of science practice. Using a situative framework, I conducted a multi-case study of five teachers, finding that: • The participants’ personal epistemologies of science differed given the varied places they learned science. Subsequently, the participants’ vision of science practice served as a framework for guiding decisions about how to set up students’ learning opportunities. • The science practice that developed in each classroom differed for each participant. Such differences reflected the participants’ personal epistemologies of science. • While each participant’s personal epistemology differed, two groups of teachers emerged based on prior learning experiences. One group of teachers engaged in authentic science learning experiences in research sites as undergraduates. Subsequently, they designed learning opportunities for students to engage in similar experiences. The second group of teachers learned science in undergraduate classrooms that promoted information memorization and recitation. Subsequently, they designed learning opportunities for students to engage in similar experiences.

B30. Learning by Collaborative Design: Curriculum Design and Content Knowledge of a Mentor Teacher
Tamara J. Heck, Michigan State University
ABSTRACT:
This study examines the science content knowledge development of a mentor science teacher throughout the first year of curriculum design and implementation of a middle school genetics unit. As a member of the curriculum design team, the mentor teacher's content understanding specifically regarding genetic expression is studied. This single case study focuses on a middle school science mentor teacher in the South. Through the development, critique, iteration, and implementation of a visualization modeling genetic expression, the content knowledge of the mentor teacher became more sophisticated. Implications for this work include possible trajectories for science mentor teacher development, as well as reflections on research practice partnerships.

B32. Using Observational Measures and Value-Added Measures to Examine Secondary Science Teachers' Instruction
Jamie N. Mikeska, ETS
ABSTRACT:
Research has shown that good teachers matter, but efforts to explain exactly how and why they matter have not provided clear cut answers within and across subject areas. Identifying and understanding the underlying mechanisms that result in more effective instruction and improved student outcomes is imperative to ensuring that every student has access to high quality teaching. This study is designed to specify the underlying mechanisms that account for improved student outcomes by examining the relationship between two measures of teaching effectiveness – value-added measures and observation measures – in the context of secondary science teachers' classrooms. Specifically, this study examines the generic and subject-specific instructional practices that 97 secondary biology teachers use to improve their students' conceptual understanding and employs hierarchical regression to determine which combination of instructional practices are most predictive of students' science achievement, as determined by teachers' value-added measures. To date, little research has targeted the validity of value-added measures in the context of teachers' instructional practice, and none has examined the extent to which value-added measures are accurate indicators of quality teaching in the area of science education.

B34. The Portrayal of the Evolution of the Horse in Textbooks and Implications for Teacher Preparation
Paul Davies, University of London
ABSTRACT:
The horse is an icon of evolution and has a long history of being used for teaching and learning about evolution and, in particular speciation. This study examines the types of diagrams that are used to illustrate the evolution of the horse in textbooks designed for use with U.K. high school students aged 16-19 years. The study categories diagrams from a range of textbooks, and Internet image searches and tests how Science pre-service teachers respond to different types of diagrams. A majority of the surveyed diagrams promote and support explanations of speciation where one species evolves into a new one (anagenesis). This contrary to how almost all speciation events occur, whereby a population is split to form new species (cladogenesis). The study finds that the types of diagram currently available to teachers do little to support them in their own understanding of "tree thinking" to explain the diversity of life on Earth. Suggestions are made regarding more appropriate diagrams that should be made available to teachers of science, or that teachers could be encouraged to produce for themselves.

B36. A Multispatial Analysis of Representation Creation while Teaching with a Digital Learning Game
Grant W. Van Eaton, Vanderbilt University
ABSTRACT:

As digital games and simulations become more commonplace in education settings, it is important to document and analyze the ways such digital learning environments fuse with the traditional discourses and spaces of formal classroom-based learning environments. This analysis identifies spaces occupied by physics concepts as a teacher integrates a digital learning game into her force and motion curriculum, as well as how she signals movement between each space. Furthermore, this analysis explores the quality of physics concepts as they move across each space in an attempt by the teacher to make physics concepts salient for her middle school students. From this analysis, the centrality of "trouble spots" arises as a potential driver for teacher professional development. Areas for future research should focus on (1) the importance of colocating concepts with objects to create representations and (2) trouble spots in transitions out of the colocated space into game or real world spaces. Patterns in trouble spots serve as guides for designing teacher professional development. Identification of these trouble spots by instructional coaches could also offer avenues for individual teacher development around science concepts and their embodiment in the objects of digital learning environments.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Poster Session B
4:15pm – 5:15pm, Riverside East

B38. How Undergraduate STEM Students Conceptualize the Problem-Solving Process: A Visual Card Sorting Approach
Pavlo D. Antonenko, University of Florida
Kent J. Crippen, University of Florida
Lauren Eutsler, University of Florida
ABSTRACT:
Open-ended problem solving causes significant cognitive discomfort for STEM learners who are used to well-defined and well-structured word problems. This study was designed to understand undergraduate STEM majors' conceptions of the problem-solving process, that is, the processes and heuristics they employ in solving a problem. Participants reviewed a thermodynamics problem, reflected on the problem-solving process and wrote down the most salient components of this process on cards. Then they arrange cards in a meaningful sequence or hierarchy and aligned them with a research-based framework of scaffolding problem solving and specific problem-solving tasks. We found that freshman and sophomore students tended to focus on the superficial features of the problem rather than the more general heuristics that would apply to other problems. Upper-level students, particularly those in engineering programs, started their models with heuristics related to exploring available information and defining the problem, whereas novice undergraduates expected to be provided with a description of the problem early in the process. These findings are consistent with the evidence reported by Chi and colleagues (1981). It seems that little has changed in the way we scaffold the development problem-solving skills since some of these findings were initially reported more than 30 years ago.

B40. Impact of Technology-Infused Learning Environments on College Professors' Instructional Decisions and Practices
Chamathca P. Kuda-Malwathumullage, University of Iowa
Soonhye Park, University of Iowa
Renee S Cole, University of Iowa
ABSTRACT:
Recent advancements in instructional technology and interactive learning spaces within undergraduate institutes necessitate college professors to effectively utilize them to facilitate students learning. While several studies have been conducted to investigate student learning gains in technology-infused interactive learning environments, studies conducted to explore the performance of college professors in such learning

environments are limited. Therefore, the purpose of this study is to investigate college professors' perception of utilizing various instructional technologies and teaching strategies to foster undergraduate student learning in technology-infused learning environments. Four college professors from a Midwestern university who taught science courses in a classroom based on the 'SCALE-UP model' participated in this study. Major data sources included classroom observations, interviews and questionnaires. The constant comparative method was utilized to analyze the data. According to the results obtained, college professors' indication of primary benefits as to conducting courses in these learning spaces included opportunities for them to get to know and interact with students and to be flexible & creative in designing classroom activities. On the other hand, college professors' indication of primary challenges as to conducting courses in technology-infused learning spaces included lack of familiarity with student-centered pedagogies and efficient classroom activity design.

B42. Student Learning about Evolution in a Misconception-Focused vs. Traditional Undergraduate Biology Class

Gena C. Sbeglia, Stony Brook University
Minsu Ha, Kangwon National University
Ross H. Nehm, SUNY Stony Brook

ABSTRACT:

Our study aims to investigate the effects of a misconception-focused introductory biology class on student learning of evolution relative to a traditional introductory biology class. The experimental group was introduced to common misconceptions about natural selection and evolution whereas the comparison group was taught additional normative scientific content. Participants in this intervention study enrolled in two introductory biology classes (comparison group [CG, n = 314] and experimental group [EG, n = 393]). We measured student's knowledge and acceptance of evolution and natural selection using several published instruments (CINS, I-SEA, and ACORNS). We used MANOVA and linear regression to analyze student learning. The intervention significantly increased the students' evolutionary knowledge at the end of the semester ($d > 0.4$). Students participating in the intervention displayed: greater understanding of core evolutionary ideas, use of more key concepts in evolutionary explanations, and fewer misconceptions. Furthermore, the linear regression model showed that when holding all other variables constant (e.g., baseline knowledge, acceptance, age, ethnicity, ELL status), the intervention had a positive and significant effect on the composite score for evolutionary knowledge. This proposal will discuss the specifics of the intervention and similarities to and differences from the conceptual change model of student learning.

B44. Nanotechnology for All: Examining Students' Motivation and Learning Outcomes in a Massive Online Open Course

Miri Barak, Technion, Israel Institute of Technology
Abeer Watted, Technion, Israel Institute of Technology

ABSTRACT:

There is a growing trend among higher education institutions towards the development of massive online open courses (MOOCs). Many studies examine the problem of students' attrition; however, little research is devoted to pedagogy and the quality of learning outcomes. The goal of this study was to examine the motivation and learning outcomes of students from different cultures who participate in a MOOC on Nanotechnology and Nanosensors. Guided by the sociocultural theory, an exploratory case study was conducted to compare between two groups of students that studied the same course but in different languages: English and Arabic. The research tools consisted of: learning achievement and motivation questionnaires, 'click data' using access logs, and content analysis of students' posts; focusing on students' learning patters and cultural differences. Findings indicated three types of MOOC learners: Random visitors, Novice students, and Expert students. Significant differences were found between the two groups in their participation curve, their understanding of nanotechnology concepts, and their motivation to learn. It appears that these differences originate from Novice

students' inability to regulate their online learning. Overall, this study provides insights about the challenges of teaching and learning in massive online open courses in the 21st century.

B46. Upper Level Biology Majors' Epistemologies

Katherine N. Mollohan, The Ohio State University
Lin Ding, The Ohio State University

ABSTRACT:
Students' epistemologies about science have been studied for decades. At the college level, research has been conducted mostly with students in introductory courses. This investigation takes a step further to better understand upper-level students' views about biology and learning biology. Utilizing a mixed method design, we surveyed undergraduate biology majors in an intermediate level course (n=102) about their epistemologies, and interviewed a subset of these students (n=15) to better understand the reasoning behind their answers. The survey results indicated that students in the intermediate level course improved in their epistemologies during the course of the semester, and the interviews revealed that students see several factors associated with their improved attitudes and learning, including an intrinsic enjoyment of the subject, experience in college, and learning how to study in college.

B48. Variation in Students' Epistemological Changes and their Relationship with Conceptual Learning Gains in Introductory Physics

Lin Ding, The Ohio State University

ABSTRACT:
Prior physics education studies have established a positive relationship between students' learning gains and their epistemological views measured at single time points (i.e., either before or after instruction). These studies, albeit informative, miss the dynamic nature of students' views about physics. In this study, we seek to investigate students' epistemological shifts in relation to their learning gains. Students' epistemological shifts were measured by the difference in their performances on the Colorado Learning Attitudes about Science Survey (CLASS) before and after a traditionally taught introductory mechanics course (ΔCLASS). Student learning gains were measured by their normalized gains on the Force Concept Inventory (FCI). Results revealed a large variation in students' epistemological change after instruction despite a near-zero shift on average. Also, while no significant overall relation was detected between ΔCLASS and FCI normalized gains, the FCI results appeared to be sensitive to epistemological changes among the lower-end students who remained below average on both the pre and post CLASS. In this case, those who experienced a positive epistemological shift achieved higher conceptual gains than those otherwise.

Strand 6: Science Learning in Informal Contexts

Poster Session B

4:15pm – 5:15pm, Riverside East

B50. Size and Scale of the Solar System: Middle School Students' Learning at a Discovery Centre

Marina Pitts, Willetton Senior High School
Grady J. Venville, University Of Western Australia

ABSTRACT:
The purpose of the research presented in this paper was to explore how an informal (out-of-school) excursion and participation in a Solar System Walk exhibit influenced middle school students' understandings of the size and scale of planets in the Solar System. The conceptual framework was formed from research that reveals students encounter difficulties in appreciating extreme scales and that direct experiences can play an important role in their conceptualisation. The research design was a multiple case study of three classes of Grade 7 (n=24),

Grade 8 (n=25), and Grade 9 (n=20) students from different school contexts. Data collection included a pre-excursion Solar System Quiz and post-excursion Solar System Diagrams, and observation prior to and during the excursion. The findings revealed that participation in a Solar System Walk activity could potentially enable Grade 7 to 9 students to comprehend concepts about the size and scale of the Solar System. However, students more readily learned the relative sizes of the planets than the distances between the planets. The findings also suggest a number of implications for the teaching and learning of scale and size through models at a science center.

B52. The Effect of Formal-Informal Instruction of Energy Concepts on African-American Students' Science Achievement and Application

Shamarion G. Grace, Flint Community Schools
Jazlin Ebenezer, Wayne State University

ABSTRACT:
The purpose of this study was to investigate whether a standards-driven, project-based Investigating and Questioning with Science and Technology (IQWST) curriculum unit on forms and transformation of energy augmented by science center exhibits had a significant effect on urban African-American seventh grade students' achievement. A mixed approach, consisting of multiple choice and open-ended question instrument and focus group interview, was used to document data. The IQWST Unit Achievement Test (IUAT) indicated that students (N=37) in the experimental group achieved scores (p

B54. Informal Science Educators' Enactment of Goals with Preschool Audiences

Michele Crowl, Penn State University
Julia Plummer, Pennsylvania State University

ABSTRACT:
Science museums and similar institutions provide visitors with a variety of ways to make meaning from their experience. Engagement at these institutions, even for children as young as three years old can provide opportunities to participate in the practices of science. This study focused on participants from informal science institutions across the United States who participated in an online professional development work. The goal of the workshop was to prepare the participants to engage their preschool audiences in astronomy through engagement in science practices. Findings suggest that the closer the participant's goal is to the goal of the workshop, the greater the uptake in material presented. Even when participants adapted their goals to match those of the workshop, they did not able to adapt the way they taught young children. In order to increase uptake, it may be important to start from the current goals of participants in ways that encourage them to include science practices among their own goal set.

B56. Communicative Patterns of Cogenerative Dialogues between High School Students and Scientists

Anna C. Barbosa, The University of Texas at El Paso
Pei-Ling Hsu, University of Texas at El Paso

ABSTRACT:
Studies suggest that working with scientists may consist of an effective way to allow students to experience science more authentically. However, issues associated with the use of scientific jargon and power distance have been reported to negatively affect communication between students and scientists (e.g., scientist' teaching difficulties). In order to improve student-scientist partnerships during internship practices, this study introduced a pedagogical tool, cogenerative dialogues (cogens). The purpose of this study is to investigate the negotiation strategies and communicative patterns that emerge during cogens between students and scientists. Our findings suggested that cogens can empower students to communicate various issues and brainstorms solutions to improve their internship practice. The implication of this study allows educators to improve the design of

internship-like programs, which may allow students to successfully transition from a school-based culture to a university culture.

B58. General and Contextual Science Knowledge among Parents of Hearing Impaired Children

Ayelet Baram-Tsabari, Technion - Israel Institute of Technology
Sophie Shauli, Technion - Israel Institute of Technology

ABSTRACT:
The hearing impaired child's potential of developing efficient forms of communication and achieving academically largely depends on parental dedication to realizing the child's potential. Among other skills and types of knowledge this requires parents to learn and understand vast amounts of scientific, medical, technological and audiological (hearing and hearing rehabilitation) knowledge quickly. The main research question guiding this proposal is: What general scientific knowledge and scientific knowledge in the field of hearing do parents of hearing impaired children have and what is the interaction between them? A pilot study was conducted 16 families of hearing impaired children age 6-15. Semi-structured interviews and questionnaires were developed to address five main topics: general scientific knowledge, contextual scientific knowledge, information resources and information seeking practices, advocacy ability, and demographics. Preliminary results indicate that health literacy might be better acquired and used if a person is scientifically literate. These literacies are the basis for engagement with science, operationalized here as parental advocacy. These findings may have educational implications regarding evidenced-based conceptualization of science literacy, health literacy and more active engagement with science.

B60. Serendipitous Engagement in Science: A Family Ethnographic Study

Dana Vedder-Weiss, Ben-Gurion University of the Negev and Tel-Aviv University, Israel

ABSTRACT:
This study aims to advance understanding of the manners and circumstances in which unplanned, undesigned Serendipitous Science Engagement (SSE) is instigated, sustained and extinguish. It is set to: (1) Propose a conceptual framework that helps to distinguish moments of SSE from other moments of learning (conceptualization); (2) Propose an empirically-based model that helps to describe patterns of SSE (characterization); and (3) Use the proposed frameworks to describe and investigate SSE dynamics. Framed by a contextualist-ecological paradigm, the study approached these goals by documenting through a family ethnography children's SSE. During one year, ethnographic data was collected in the context of the author's own family, documenting the ways her children (aged 8.5, 11 and 15) serendipitously engaged and disengaged in science content and practice in a wide range of every-day settings. Analysis of 90 audio-recorded episodes, considering the contextual, personal and social aspects of engagement (Falk & Dierking, 2000) yielded an 11 facets' model that characterizes SSE. A turn-by-turn micro-analysis of engagement dynamics across one short audio-recorded episode demonstrated how analyzing SSE episodes using this framework, serves to highlight emerging themes that intertwine with SSE evolution.

B62. "We're Education Students, Make Sure you Write that Down. This isn't Biology class!"

Catherine Scott, Coastal Carolina University

ABSTRACT:
The Turtle Project was developed as a means to expose elementary education majors to fieldwork and use of scientific tools, with hopes of improving their content knowledge regarding reptiles and citizen science, and impacting their pedagogical practices to include more field-based studies. As a result, this study addresses the following questions: In what ways does engagement in an informal, citizen science project impact preservice teachers' scientific content knowledge and perceptions of citizen science in the classroom? What meanings do participants make of their experiences in citizen science and how it applies to the classroom? This study was guided by a mixed-methods strategy for data collection and data analysis.The participants in this study were

thirteen undergraduate education majors at the institution. Participants in the study demonstrated a growth in knowledge regarding citizen science (sig. at 0.01) and life science content (sig. at .015).Through interviews, field observations, and social media posts, three major themes emerged to describe participants' meaning making. The three themes were: a) a sense of social responsibility, b) ownership of the project, and c) a desire to teach children about the importance of the local environment.

Strand 7: Pre-service Science Teacher Education
Poster Session B
4:15pm – 5:15pm, Riverside East

B64. Fostering Pre-service Teacher Attention and Response to Student Ideas
Kathleen Crucet, University of Wisconsin-Madison
Leema Berland, University of Wisconsin-Madison
ABSTRACT:
Professional vision is considered to be a central component of teaching expertise, and it is regarded as fundamental for acting professionally and reflecting in classrooms (Sherin, 2007). Studies on mathematics and science instruction show a positive correlation between teachers' professional vision and students' performances (Kersting et al., 2012; Roth et al., 2011). This raises the question of how professional vision can be fostered in teacher education. For this purpose, video-based teaching/learning environments are often used regarding different groups and domains (Blomberg et al., 2013). In primary school science education, there is a lack of controlled studies investigating the efficiency of such learning environments. In the present study, a case-related video- and text-based program (n=32) has been compared to a case-related, text-only based program (n=36), and to a control group without case-based learning elements (n=16) in order to foster the professional vision of undergraduate students concerning learning support including aspects of cognitive activation and content-related structuring. To measure professional vision, a standardized video test was applied. Initial results of our study show that the group additionally trained with videos could outperform the other two groups in professional vision regarding the topic trained in both case-related programs.

B66. Investigating the Development of Secondary Science Methods Students' Orientations and Practices toward Teaching Science.
Stephen B. Witzig, University of Massachusetts Dartmouth
Todd Campbell, University of Connecticut
ABSTRACT:
Reforms in science teaching and learning are at the forefront of science teacher educators' research and practice. A new framework for K-12 science education is shaping science standards nationwide. Here, we investigate how secondary science methods students conceptualize a new research-based teaching framework. We follow the progression of student ideas through multiple methods and characterize students' science teaching orientations. There is a need for research to provide examples of not only what knowledge future science teachers have for teaching, but also how they conceptualize their knowledge and beliefs for teaching. Our qualitative study was guided using narrative methodology to address the following over-arching research question: How do secondary science methods students' orientations and practices toward teaching science develop over time while engaged in a science methods course? Our findings indicate that students transitioned their thinking and planning from a more teacher centered classroom to a more student centered/teacher guided classroom. We discuss the implications of the findings as well as provide suggestions for future research in this area. Our hope is that our study continues the dialogue about the role we take on as science teacher educators in facilitating science teaching and learning with the next generation of science teachers.

B68. An Exploratory Investigation of K-8 Pre-Service Teachers' Science Pedagogical Preferences
Selcuk Sahingoz, Western Michigan University
William W. Cobern, Western Michigan University
ABSTRACT:
When it comes to science pedagogical preferences, how much difference does a science teaching methods course make in K-8 pre-service teachers' pedagogical preferences? This study investigated possible answers to this question with respect to instruction for science content learning. The study employed eight items from the Pedagogy of Science Teaching Test (POSTT) using a mixed-methods design. The data were collected from twenty K-8 teacher education students enrolled in lower division science courses at a large Midwestern public university. Each student's responses to the items were summarized as a pedagogical preference profile and a subset of students was subsequently interviewed so that they could explain their responses to the POSTT items. The results suggest that many participants have a tendency toward the use of inquiry instruction; however, the participants who had not taken a science methods course were more likely to choose a direct instruction response. When both types of participants chose similar instructional preferences, they did so for different reasons. The findings also indicated that the participants who had taken the science methods course did not always respond to an item in the same way.

B70. Preparing Elementary Pre-service Teachers to Teach Socioscientific Argumentation: From Theory to Practice
Maria Evagorou, University of Nicosia
ABSTRACT:
The inclusion of SSI in the curriculum offers a means of expanding both the curriculum and the range of instructional practices commonly experienced in the school science classroom. An area that is still relatively unexplored however is how teachers, especially elementary school teachers, understand and approach everyday science and SSI in their teaching. Drawing from this gap in the literature, this study aims to explore: (a) The difficulties that elementary pre-service teachers face as learners with ssi argumentation, and (b) How and whether they transfer their knowledge of ssi argumentation in their designs of lesson plans, and their teaching practice. The participants of this study are twelve students studying to become elementary school teachers. The findings support that elementary pre-service teachers can appreciate the importance of teaching ssi, and can design ssi lessons. However, their lack of content knowledge seems to influence their ability to implement the lessons succesfuly. Implications from this study are associated with finding ways to support teachers in understanding and accepting uncertainty in science, and based on that to find consistent ways to evaluate argumentation, especially in socio-scientific contexts.

B72. Preservice Elementary Science Teachers' Ideas about Engineering
Mandy Biggers, Penn State University
ABSTRACT:
Engineering is a newly explicit focus of the Next Generation Science Standards, and is unfamiliar to many teachers both preservice and inservice. One baseline area of research is to find out teachers' preexisting ideas about engineers and engineering. This research has been conducted with inservice teachers, but has yet to be investigated with preservice teachers. This study researched 120 preservice elementary students' ideas about engineers and the work they do. Data was collected through a survey previously used for both inservice teachers and K-12 students, and revealed that while many preservice teachers had a strong understanding of engineers' work, there were also misconceptions. One such misconception was a lack of understanding of the design aspect of engineers' work, and thinking they do things such as build houses and fly planes. This study has implications for teacher education, professional development, and eventually classroom practice. It is a first step in understanding preservice elementary teachers' ideas about engineering so that further research can be conducted

on how to best integrate engineering design into teacher education programs and professional development in order to encourage more teachers to integrate engineering into their science lessons and classrooms.

B74. Heuristic Teaching of Variable-Based Investigation Planning To Science Pre-Service Teachers in the Upper Primary Years

Annemarie Hattingh, University of Cape Town

ABSTRACT:
In primary schools science is often taught by generalist teachers who have limited experiences of scientific inquiry and they often hold naïve views of the nature of science (NOS). How can this limitation realistically be addressed in an intense one year professional qualification following any Bachelors degree in a methods course? Being aware of the critiques of the scientific method, an activity-movie intervention focusing on the scientific method used as a heuristic led to the research questions: 1) Is the heuristic effective at enabling effective planning of an experimental investigation? 2) Does it promote an appropriate view of NOS? Using a mixed methods design, a knowledge pre-test of planning by a sample of 50 prospective teachers and a written planning task resulted in 50 % being able to do advanced planning. The Student-Understanding- of-Scientific Inquiry survey showed no significant gains but qualitative data highlighted that the heuristic may have the opposite effect to that claimed by critics of the scientific method because it has not led all students to believe that all scientists follow a rigid formulaic set of steps. Instead, it helped some realise that scientists use creativity in the design stage and that science is tentative.

B76. STSE Biology Discourses and their Role in Fostering Citizenship Orientation among Preservice Teachers

Christina A. Phillips-MacNeil, York Region District School Board

ABSTRACT:
Discussions and activities centred on how science relates to technology, society and the environment (STSE) are a positive step forward in science education. Additionally, framing science in the context of STSE may enable individuals to make more informed choices about various consumer products, lead to increases in critical thought where deeper insights as to the benefits and risks of a situation are more effectively evaluated and to more participatory citizenship orientations where individuals may feel empowered to take action on given issues. This study (i.e., my doctoral dissertation), will explore the role of citizenship orientation in the preservice biology classroom through the use of case studies. Document analysis and discourse analysis will be used to explore citizenship orientation in the biology preservice classroom.

B78. Informal Science Approaches to Teacher Preparation: Beginning Elementary Teachers' Ideas about Science Teaching and Learning

Lucy Avraamidou, University of Nicosia, Cyrus

ABSTRACT:
The purpose of this collective case study was to explore the ways in which three different informal science experiences in the context of an elementary methods course influenced a group of prospective elementary teachers' ideas about science teaching and learning as well as their understandings about the role of informal science environments to schooling. In order to address this question data were collected in a period of an academic semester through the following sources: journal entries for each of the three experiences, a personal teaching philosophy statement and a two-hour long semi-structured interview with each of the twelve participants. Open coding techniques were used to analyze the data in order to construct categories and subcategories and eventually to identify emerging themes. The outcomes of the analysis showed that the inclusion of informal science experiences in the context of teacher preparation has the potential to support beginning elementary teachers' development of contemporary ideas about science teaching and learning related to: inquiry-based science, the nature of scientific work and the work of scientists, connecting science with every day life, and making science fun and personally meaningful.

B80. Exploring Pre-service Secondary Science Teachers' Perceptions about Scientific Models
Eunmi Lee, DePaul University
ABSTRACT:
The purpose of this study is to examine pre-service secondary science teachers' understanding and instructional use of models and modeling. Ten pre-service teachers participated in a three-phased data collection process. The study reveals pre-service teachers' understanding and use of models is far from the notion of explanatory models that the Framework and NGSS highlights. Particularly, pre-service biology teachers' understanding and use of modeling aligned with the notion of physical models while chemistry and physic teacher candidates hold an understanding of models close to the notion of conceptual models or explanatory models. The findings address the need for systematic support for pre-service teachers to authentically engage in the practices of science for the enhancement of major scientific ideas.

B82. Preparing Science Teachers to be Effective Educators: The Noyce Pathway to Science Program
Andre M. Green, The University of South Alabama
ABSTRACT:
The Noyce Pathway to Science program explores three factors as it relates to preparing science teachers. Those factors were the recruitment of high quality students, the preparation of those students in a graduate science education program, and each teacher's feelings of being prepared to transition into the classroom from their own perspective after two years of employment as a science teacher. This study examines the participants' perspective of their preparation after having completed the Noyce program. The study also explores the effect of a redesigned alternative certification program on these graduates as the program significantly increased clinical field experiences while shortening the time to complete the certification putting more qualified science teachers into classrooms.

Strand 8: In-service Science Teacher Education
Poster Session B
4:15pm – 5:15pm, Riverside East

B84. Learning Reform-based Science Instruction: Results from a Statewide Professional Development Program for Beginning Science Teachers
Shannon L. Dubois, University of Virginia
Jennifer L. Maeng, University of Virginia
Randy L. Bell, Oregon State University
ABSTRACT:
While there is some general understanding of beginning science teacher learning and science instruction in the United States, little is known about how science-specific professional development (PD) programs for beginning teachers impact science teacher learning and instruction. To increase the knowledge in this area, this study investigates the impact of a statewide PD program on beginning science teachers' confidence in, barriers to, and implementation of reform-based science instruction. This is a randomized controlled trial investigation PD of 74 beginning science teachers in two cohorts. The data consisted of perceptions surveys, PD observations, interviews, and classroom observations. Results suggested that the PD program was moderately effective in developing participants' confidence in and implementation of PBL, NOS, and inquiry instruction. Additionally, data revealed that perceived barriers to implementing reform-based instruction were both institutional and related to people. Finally, all types of reform-based instruction were more frequently seen in treatment than control participants' practices, yet the implementation of these types of instruction developed differently across the first two years. The study suggests the need to provide ample opportunities for beginning

science teachers to learn reform-based instructional approaches beyond initial certification programs, and that science-specific PD programs can be a form of ongoing support.

B86. Teachers-as-Designers: Promoting Teacher Professional Development to Advance Inquiry Learning in the Outdoors Using Mobile Technologies

Keren S. Levy, Technion
Tali Tal, Technion
Yael Kali, University of Haifa

ABSTRACT:
Inquiry in the outdoors can promote cognitive, social, and affective learning outcomes. Therefore, it is embedded in the science curriculum. However, teachers avoid teaching inquiry-based learning in the outdoors because of the many challenges they face. Mobile technologies may support inquiry in the outdoors. However, we need to support teacher professional development (PD) in order to promote their independence in guiding outdoor inquiry. The Teachers as Designers approach could promote the implementation of new learning materials by involving teachers in the design of such materials. In this study, we explored the way the Teachers as Designers approach contributes to teachers' professional growth and to the implementation of mobile technologies to promote teaching of inquiry in the outdoors. The participants included 20 teachers who enrolled in a special PD in which they designed their own technological tools for inquiry in the outdoors. Data sources included: a) observations, b) teachers' documented activities in websites, and c) nine interviews. Our findings showed that most of the teachers were enthusiastic about the skills they acquired for integrating technology in their teaching, and some have implemented similar tools in their classrooms. The study demonstrated a PD model which leads to changes in teacher practice.

B88. Lesson Study Inspired Professional Development for Science Teachers

Morten F. V. Lundsgaard, University of Illinois
Chris P. Cunnings, University of Illinois

ABSTRACT:
This paper discusses how an adapted Lesson Study professional development model for high school science teachers support changes in teachers' knowledge and beliefs, professional community, and teaching-learning resources. In its adapted form, the PD-model combines the Lesson Study and the "Video Club" PD models, by substituting teachers' direct observations of their peers' instruction with video clips that are shown in study group sessions. The study group sessions follow a summer session during which teachers develop lab-centered week-long units of instruction that are implemented in the school year. The summer session, study group sessions, and the implementations are all videotaped. These videos form the core of the data used in the study of the PD-model presented in the paper. The analysis of the video data is supplemented with analysis of unit plans and student artifacts. The data used in this paper were collected during the first two years of the PD-program.

B90. Increasing the Impact of a Large Urban School District in Science Through Teacher Professional Development

Donald Wink, University of Illinois at Chicago
Dean Grosshandler, University of Illinois at Chicago

ABSTRACT:
The "Midwest Urban Teacher Institutes" (MUTI) is a federally-funded partnership of five universities and the school district of a large city in the Midwest. Its aim is to increase the pedagogical and leadership skills and content understanding of high school science and math teachers through a school leader-team approach. Over 250 teachers from 80 schools have participated in MUTI programs over the five years of the project. The MUTI teacher program includes several components in addition to networking programs, including coursework in mathematics, physical science, and life and environmental science; workshops on leadership and teaching; and

improved curricula for schools to use in 12th grade capstone and AP classes. We address two major questions in this paper: 1) How have STEM faculty, leadership workshop leaders, and district and school administrators impacted teacher practices for improved student outcomes? and 2) How can a large urban program leverage and build on the introduction of the Next Generation Science Standards and changes in the AP Chemistry curriculum and assessments to increase teacher effectiveness in the midst of continuing district leadership changes?

B94. Science Teachers' Practices of Constructing Arguments against Skeptical Theories on Climate Change
Asli Sezen-Barrie, Towson University
Nicole Shea, University of Delaware
ABSTRACT:
This study aims to examine teachers' initial practices of constructing written arguments about climate change in an effort to determine how teachers make sense of climate change and what resources they draw on to support their reasoning. The data of this study involves the written arguments of 24 Maryland and Delaware teachers collected through a survey, "Scientific Argumentation on Climate Change." Each question of the survey starts with a claim commonly held by skeptics. As a result of the frequency analysis, we found that although most of the teachers disagreed with the skeptical theories, there were significant numbers of teachers who wrote, "I don't know" or agreed with the skeptical theories. A more detailed discourse analysis helped us identify which resources are used and the way these resources are referred to in teachers' evidences. For further professional development, the findings suggest providing teachers with the underlying scientific concepts of climate change in order to respond to skeptical theories by using evidence, supporting teachers in the evaluation of information to integrate data into their own classroom culture, and helping teachers in the process of constructing a strong scientific argument with an effective rhetorical reference is a complex practice for teachers.

B96. Urban Science Teachers' Beliefs, Perceptions and Implementation of CCSS for ELA/Literacy within Interdisciplinary Science Inquiry
Michelle R. Eades-Baird, University at Buffalo
Xiufeng Liu, State University of New York at Buffalo
Bhawna Chowdhary, State University of New York at Buffalo
ABSTRACT:
The goal of this study was to explore science teacher beliefs, perceptions and practices surrounding the implementation of the Common Core State Standards (CCSS) for ELA/Literacy within the context of their Interdisciplinary Science Inquiry (ISI) - based instruction. This proposed study is situated within an NSF-funded teacher professional development program between 12 public schools and 2 public universities in the North Eastern United States. This study utilized a multiple case study approach to investigate the following research questions: (1) How do science teachers demonstrate understanding of interdisciplinary science inquiry? (2) What relationship, if any, exists between teachers' understanding of interdisciplinary science inquiry and their implementation of CCSS for ELA/Literacy in the science classroom within the context of ISI? Data sources included teacher interviews, classroom observations and physical artifacts. The findings in this study reveal that teachers' understanding and conceptions of interdisciplinary science inquiry played a significant role in how they integrated the CCSS for ELA/Literacy within their classroom instruction.

B98. Argumentation-in-Practice: Using Action Research to Develop Argumentation Practices in a Secondary Science Classroom
Andri Christodoulou, University of Southampton
ABSTRACT:
For a number of years now there has been increasing interest in the way that argument can be utilised in science education. Educational reforms now incorporate argumentation with reports such as Taking Science to School

and the Next Generation Science Standards (NRC 2007, 2012) including argumentation as one of the scientific practices that should be taught in K-12 science education. However, a number of challenges have been noted when teachers attempt to teach science as argument. This study presents a qualitative exploratory case study of an in-service science teacher's engagement in an action research professional development program. The support and opportunities for reflection provided during the school year, allowed her to identify elements of her practice that she wanted to develop in order to help her students learn better. Perceived impact of her changing practice on her students' learning, especially in relation to their use of the language of science, their attitudes towards collaborating, and their ability to use evidence in support of their claims, was found to facilitate change. Changes were also noted in moving from construction to evaluation of evidence and arguments, an aspect found to be a challenge for teachers trying to teach science as argument.

Strand 9: Reflective Practice
Poster Session B
4:15pm – 5:15pm, Riverside East

B100. A Poster of the Model for Socio-culturally Relevant Instructional Practice
Olufunmilayo I. Amosun, University of the Western Cape
ABSTRACT:
This theoretical paper focuses on teacher development towards a more socioculturally-relevant and constructive, instructional and intellectually congruent professional practice/praxis. Education is a social enterprise enacted within a social space and set in social activities by social actors. For teachers to engage in instructional practices that are unstructured in cultural and sociological frameworks is incomplete and constitutes a form of symbolic violence. It becomes imperative that educational research, especially science education, begin to explore critical theories and socio-cultural perspectives from various fields to generate emancipative, conscientizing model of pedagogy. The study from which this poster is derived breaks out of the mould by aggregating a number of emancipatory theories and consciously pushing their boundaries to formulate a model that serves as a conceptual/analytical tool for teachers' obligatory engagements towards socio-culturally relevant instructional practice. Each of the three domains of the model requires skills in conformity with the taxonomy of learning objectives (attitudinal, cognitive and practical). The aggregation of intercultural sensitivity development models, ideologies of multicultural practice and pedagogy for equitable instructional practice tailored to cognitive, attitudinal and practical obligatory engagements provides a conceptual checklist for socio-culturally relevant professional practice, useful for evaluating levels of professional competence in schools with multi/socio/intercultural diversity.

Strand 10: Curriculum, Evaluation, and Assessment
Poster Session B
4:15pm – 5:15pm, Riverside East

B102. Examining Secondary Science Teachers' Formative Assessment Practices in Biology Instruction When Using Computer-based Interactive Modules
Melissa A. Jurkiewicz, University of Nevada
J. Steve Oliver, The University of Georgia
Georgia Hodges, University of Georgia
ABSTRACT:
The purpose of this study was to explore how the integration of instructional technology into a biology high school course supports and constrains teachers' formative assessment practices. The specific technologies

involved in this study were interactive 3-D computer modules involving cellular transport, coupled with a web application, the SABLE system, which allows real time monitoring of students' work. Three biology teachers were participants in the research. Interviews with those teachers and observations of their implementations of the cell unit were the primary sources of data for the research. Several characteristics inherent in the instructional technologies supported the teachers' formative assessment practices. The computer modules and the SABLE system elicited, gathered, organized, and stored evidence of student learning, enabling teachers to devote more energy towards interpreting and acting on the elicited evidence. However, several characteristics inherent in the instructional technologies also constrained teachers' formative assessment practices. For instance, the cluster of open-ended response questions towards the end of the modules and the lack of an automated grading component hindered teachers' abilities to quickly assess the data from the open-ended response questions. This proposal discusses implications for science teacher educators and developers of instructional technology.

B104. Engineering Design Process Skills Coverage in K-12 Science Curricula
Vivien M. Chabalengula, University of Virginia
Frackson Mumba, University of Virginia
Sonia A. Bendjemil, University of Virginia
ABSTRACT:
This study investigated the extent to which engineering design process skills are covered in K-12 engineering programs. Nine programs that are widely used in the United States were analyzed via document content analysis method using the K-12 science education framework. Results revealed that: developing possible solutions, and actual designing of models/prototypes are highly covered in many K-12 engineering curricula; specification of clear goals, criteria, and constraints had medium coverage; defining and identifying engineering problems; optimizing the design solution; testing or demonstrating how a model/prototype works were lowly covered; whereas making iterations to improve designs was not explicitly covered. Across discipline-specific units, most of the engineering design skills were addressed in physical science units, followed by earth science, and least in life science. The implications of these results to science teaching and learning as well as development of next generation science materials are discussed. Key Words: coverage, engineering design process skills, K-12 engineering programs, K-12 science curricula

B106. Using Rasch Measurement to Validate the Instrument for Evaluating Secondary Chemistry Classroom Teaching and Learning
Peng He, Northeast Normal University (China)
Changlong Zheng, Northeast Normal University (China)
Xiufeng Liu, State University Of New York At Buffalo (SUNY)
ABSTRACT:
This study intends to develop a standardized instrument for measuring chemistry lesson levels in secondary school. Revising the instrument of ESEPrSCT, The initial instrument contains 13 items with six Likert-scales to describe chemistry lesson levels. The results present both additional evidence for the validity and reliability of this initial measurement instrument and specific aspects for further improvement. The final instrument can be used as a tool to evaluate the quality of chemistry lessons in national teaching skills competitions and it can be employed in a teaching quality assessment system for measuring teachers' professional development.

B108. Creating Early Elementary Assessments for the Next Generation Science Standards
Jenny D. Ingber, Bank Street College of Education
Christopher Lazzaro, Columbia University
ABSTRACT:

In this poster we describe how we unpacked and articulated performance expectations to create assessment tools for the Next Generation Science Standards, with a focus on kindergarten and second grade students. Using a Claim-Evidence-Task (CET) framework we elaborate how evidence can be derived from students' participation in science practices as to their achievement of standards. We implemented the assessment tools that resulted from the CETs we generated in classrooms in a large, urban city. Through close work with the teacher to align curricular activities with the assessment, we were able to document cases of student experiences both learning and demonstrating their learning of scientific phenomena through engaging in science practices. This gave us insight into the usability of CETs for creating assessment tools that measure achievement of NGSS by young elementary students.

B110. Fostering and Assessing Model-based Learning of Human Body Systems through Simulation-Based Investigations

Barbara C. Buckley, WestEd
Daniel Brenner, WestEd

ABSTRACT:
The NSF-funded Human Body Systems project has developed and is testing simulation-based instructional modules and a summative benchmark assessment for high school biology. Our goal is to help students integrate and animate too often fragmented, inert biology knowledge into multilevel mental models of the complex systems of the human body. This paper describes [1] the design of three instructional modules with transparently embedded tasks for formative assessment and one summative benchmark assessment and [2] pilot testing in the classrooms of five biology teachers. IRT analyses of response data from 543 students in biology, sheltered biology, and physiology classes were conducted, along with external reviews, think-alouds, and teacher interviews. Preliminary IRT analyses of the benchmark assessment items indicated good fit among the assessment items with reliabilities ranging from .82 to .90. The range of item difficulty estimates was larger than the range of person ability estimates indicating that the items bracketed the knowledge of the students. Results from analyses of the data collected while students used the modules were triangulated to inform revisions and establish the appropriateness of the modules for different types of biology classes. The revised suite of modules will be field-tested in a small RCT.

B112. Scientific Literacy and Interdisciplinarity Measured by Multidimensional Test and Concept Mapping

Priit Reiska, Tallinn University
Katrin Soika, Tallinn University

ABSTRACT:
How and when learning appears is a principle question of teaching and learning. It is expected that school graduator has reached to a development level, where the individual is able to think critically; to plan ones studies and future; to transfer knowledge from one discipline to another, etc. There are difficulties in reaching the above-mentioned outcomes at school. According to different curricula, disciplines at schools are often taught separately and by different teachers. It is complicated for students to connect one discipline based and studied knowledge to another. The Next Generation Science Standard pointed out that in there are some important cross-cuttings in science education. In this research we are describing an analysis of a study, where three-dimensional PISA-like test and concept mapping were carried out among 343 Estonian 10-th grade students. Students' scientific literacy skill (measured by PISA-like test) are compared with interdisciplinary approach (measured by a concept map using focus question and 30 pre-given concepts). We calculated interdisciplinarity index, where quality and quantity of concept map were considered. The analysis pointed out, that results of interdisciplinary approach and scientific literacy skills are comparable and students do not create many interdisciplinary high scored propositions in their concept maps.

B114. Knowledge of Assessment of Chemistry Teachers

Carmen Fernandez, Universidade de São Paulo
Marina A. Tacoshi, High School teacher

ABSTRACT:
The knowledge of assessment is considered one of the components of pedagogical content knowledge (PCK) by some authors and for others is considered one component of the knowledge base for teaching. It is recognized the strong link between knowledge of the educational goals and the knowledge of assessment procedures. In this work, results focused on ten chemistry teachers are presented with the main goal of documenting the knowledge of assessment practices and its close relationship with the purposes and educational aims. The results are based on semi-structured interviews, schools' educational projects, questionnaires, evaluations and teacher lesson plans. The data suggests that there exists an inconsistency in the discourse regarding general education and chemistry education. We observed a strong tendency toward the teacher-centered approach and summative assessment. The results show that, in general, the investigated chemistry teachers lack the intrinsic knowledge to elaborate questions that assess students´ higher-order thinking, to use assessment results to improve teaching and learning, to inform planning, and ultimately, to perform assessments for learning that regulate and promote the learning process, in line with their own beliefs regarding the objectives of chemical education. As a result we can infer problems in other PCK components of these teachers.

B116. The "Noise" In, and Of Representations: An Analysis of General Chemistry Textbooks

James M. Nyachwaya, North Dakota State University
Merry Gillaspie, Wartburg College

ABSTRACT:
This study looked at representations in general chemistry textbooks to determine elements of the representations likely to enhance or hinder learning of associated concepts. Any features that could hinder a student's ability to use or understand a representation were considered to be 'noise'. We adapted the Graphical Analysis Protocol (GAP) to look at the proportion of each representation used, the function of each representation, the physical integration of representations with associated text, the presence and nature of captions and labels, whether representations were indexed, and the number of representations that required conceptual integration on a given page. Results indicate that symbolic representations were most prevalent, and on average, each page had at least 3 representations. While most representations served a representational function, some were decorative. While most representations were directly integrated with text, some of the remaining representations were separated by a whole page from associated text. While most pages had 2 representations that required integration with text or other representations, some pages had as many as 6 representations requiring integration with text to understand a concept.

B118. Using Rasch Model to Estimate and Compare Undergraduate Students' Chemistry Competency across Different Classes that Adopt Mastery Learning

Shannon Sung, Spelman College
Lisa Hibbard, Spelman College

ABSTRACT:
College teachers are often perplexed by the effectiveness of their innovative instructional methods implemented in distinct group of classes. This study recorded how the use of a high-stake chemistry test provides the bases for the instructor to compare students' learning outcome. In this study, the chemistry instructor adopted a combination of instructional strategies (i.e., gates, blended, and enhanced-blended learning) in distinct classes. This study intends to investigate whether students' ability increases across classes. The participants (N = 126) were chemistry majors taking the second general chemistry course in the first year of college. The students' responses for the same high-stake chemistry exam (n = 70) administered to four classes were tabulated into dichotomous format and analyzed with the Item Response Theory (IRT). The application of the IRT offers a less labor-intensive approach for obtaining a meaningful result in order to communicate the effectiveness of

adopting innovative pedagogies. Specifically, the Rasch model in the IRT was applied to obtain item difficulty and students' chemistry competency levels which are plotted on the same scale of Wright map. One-way ANOVA demonstrated that there were significant differences in chemistry competency levels among the classes using different instructional methods. Educational implications are discussed.

Strand 11: Cultural, Social, and Gender Issues
Poster Session B
4:15pm – 5:15pm, Riverside East

B120. Identifying Sociocultural Challenges of Arabic-speaking ESL Students in Secondary Science
Gihan Fradi, Wayne State University
David Grueber, Wayne State University
ABSTRACT:
This naturalistic study investigates the experiences of 3 Arabic-speaking ESL students in the secondary science classroom. At the time the study began the three students had immigrated to the US in the last 9 to twenty four months. The school is located in a community with a large number of Arabic-speaking residents. The study occurred in two phases. First, a phenomenographic approach was used to identify categories of experience in the science classroom. In the second phase, the study was expanded to include interviews with the teacher and the types of classroom practices that count as successful scientific participation in the classroom. This study raises questions about the relationship between science content, literacy, and English proficiency for bilingual/bicultural students.

B122. Esperanza's Persistence in the Face of Adversity
Michele J. Mann, University of Texas Austin
Jair J. Aguilar, University of Texas Austin
ABSTRACT:
Science, technology, engineering and mathematics (STEM) degrees are not equally accessible to all people. Less than 20% of the Hispanics that begin college as a STEM major in 2004 completed a STEM degree by 2009 . Thus, there is a need to have a better understanding of the challenges faced by Hispanic students and how the development of a science identity increases the likelihood of completing a STEM degree. This case study of a Hispanic female addresses this issue. It looks at the connection between her developing a science identity and her pursuit of a STEM degree. Parental support, science extracurricular activities, and being part of a science community are all ways that students can build their own science identity however these factors are more likely to be absent for students from underrepresented groups. For our participant it was found that the practice of science, as opposed to doing school science, proved critical for her development of an identity. She was also a part of a science community, which are not always present in schools. It will be important to foster such communities in order to support the development of scientific identities among underrepresented minorities.

B124. Research Experiences for Students with Disabilities: Changing Perceptions
Loran Carleton Parker, Purdue University
Wilella Burgess, Purdue University
ABSTRACT:
PWDs are an underutilized human resource in scientific research. A concerted effort to promote the entry and, ultimately, success of PWDs in practice-based research careers is needed. Current efforts at the secondary and post-secondary education level emphasize equity of access, rather than inclusion in classroom or laboratory activities. As educational researchers, reformers and the National Science Foundation (1996) extoll the value of "hands-on" authentic practice in science education, it is essential that PWDs gain access not only to the science

classroom, but also to the practice of science in the laboratory and field. The Institute for Accessible Science (IAS) targeted physical and attitudinal impediments to the inclusion of persons with disabilities (PWDs) in laboratory-based research. IAS recruited seven students with disabilities currently pursuing or interested in pursuing laboratory-based science at the post-secondary or post-graduate level to complete a summer research experience at a university. During the summer research, students with disabilities developed their science identity and enhanced their aspiration for graduate school. Their able-bodied peers decreased their stereotypical views about PWDs. Additionally, the colleagues in their research groups broadened their perceptions of what PWDs can accomplish in science and became advocates for PWDs in science.

B126. Appropriating Scientific Vocabulary by College Students with Diverse Ethno-linguistic Backgrounds in Chemistry Laboratories

Ruth B. Cink, Auckland University of Technology, New Zealand
Youngjin Song, University of Northern Colorado

ABSTRACT:

The purpose of this multiple case study is to explore how college students with diverse ethno-linguistic backgrounds appropriate chemistry language as a way to look at their discursive identity and cultural border crossing during first semester general chemistry laboratories. The data was collected in two major forms: video-taped laboratory observations and audio-recorded interviews. All transcribed data from videos and interviews were analyzed in three phases in terms of scientific vocabulary. Our findings indicate that the ethno-linguistically diverse participants were able to appropriate many scientific vocabulary words, especially a large number of overlap vocabulary (words used in both lecture and laboratory settings) compared to the number of laboratory vocabulary. This implies cultural border crossing in the laboratory setting was not an easy task due to the language of science. Participants also appropriated Dual Meaning Vocabulary (DMV), which has both everyday and scientific meanings, as well as Cross Meaning Vocabulary (CMV), which has both academic and scientific meanings. It seems that participants' English learning experiences shape their ability to appropriate DMV or CMV into their discursive identities. The analytical framework and findings of this study will provide implications for researchers and those who teach diverse student population.

B128. Training Next Generation Science Educators for a Culturally Relevant Teacher Education Program

Meshach Mobolaji Ogunniyi, University of the Western Cape

ABSTRACT:

In the pursuit of equity and justice for all, and in response to the emerging multicultural society resulting from political freedom in an African country (henceforth X), the Department of Education (DOE) implemented a curriculum policy which required teachers to integrate science with indigenous knowledge (IK). This study, a part of a larger study, provides a synopsis of how a professional science teacher education program used a dialogical argumentation instructional model (DAIM) to equip a cohort of 23 participants (10 science educators and 13 teachers) with instructional skills for a culturally relevant science-indigenous curriculum. An analysis of the data derived from a questionnaire, reflective diaries and video recordings showed DAIM to be effective for: (1) enhancing the participants' awareness about the educational and cultural merits of IK; (2) showing them how IK could be integrated with science in a classroom context; and (3) for changing their negative perceptions about the new curriculum to a positive one.

B130. Addressing Pre Service Teachers' Readiness to Teach in Increasingly Diverse Classrooms

Mary K. Nyaema, University of Iowa

ABSTRACT:

Pre-service teachers in Science are being trained on new practices based on educational reform and innovative teaching approaches that target multicultural classrooms, but they are having difficulty implementing these strategies in actual classrooms and gaining experience as strong teachers in this field. Teachers are not

adequately being prepared to meet the challenges that come with teaching in increasingly diverse classrooms. The study takes an in-depth look at strategies that have been used to tackle the issue of cultural responsiveness in the science classroom. The challenges that arise from pre-service teacher beliefs are addressed and strategies used by teacher education programs to develop a more workable framework for preparing multicultural competent pre service teachers, especially in the field of science are embraced. Researchers have made credible efforts in trying to create models and frameworks based on cultural responsiveness to guide pre-service teachers in their endeavors to develop multicultural practices in the classroom. However how sustainable this is in practice still needs to have tangible results in form of improved performance and equitable science assessment of diverse groups. This is not far from being attained. What is needed is a more convincing strategy in engaging pre service teachers to see that all theirs efforts they have learnt in their teacher preparation courses are not going to waste. Integrating multicultural perspectives should be in all areas of their teacher education programs as opposed to a single course that offer little or no meaningful development in their multicultural practices. Most importantly, support should come in all forms be it peers, mentors, teachers and parents so that these future teachers do not shy away from putting into practice what they have learnt. Instead they should be able to embrace multicultural values as a lens through which all students, regardless of background have equal opportunities for success.

B132. Gender Differences in Students' Motivational Beliefs and Science Achievement over Grades in Taiwan
Pey-Yan Liou, National Central
ABSTRACT:
The purpose of this study is to examine the gender differences in fourth and eighth grade students' self-concept and intrinsic value of learning science and their relationships with science achievement in Taiwan based on the Trends in International Mathematics and Science Study (TIMSS) 2011 data. Statistical analyses indicated that girls have lower motivational beliefs than boys, and the differences of their motivational beliefs are even greater over grades. Meanwhile, the two motivational beliefs explain boys' science achievement than girls' over grades. This study sheds light on gender differences in students' motivational beliefs in learning science and their relationships with achievement over grades.

B134. Challenging Master Narratives: Using Counterstorytelling to Transform Research on Racial Inequities in the Science Doctorate
Senetta Bancroft, Grand Valley State University
Nidaa Makki, University of Akron
ABSTRACT:
Research and policy addressing the persistent underrepresentation of students of color (URSC) in science doctorates remain fixated on increasing racial diversity for U.S. economic security. Further, studies of racial inequities in science doctorates are predominantly informed by socialization theories, which maintain the misconception of URSC as socioculturally deficient. Informed by critical race theories, fictive-kinship, and forms of capital I use counterstorytelling to recast racial inequities in science as a problem of social justice not economics. I holistically explore racial inequity in science doctorates by incorporating theories that tackle both socialization and the U.S. legacy of marginalization of minorities in institutions of power. Through interviews I examined the experiences, from elementary school to current careers, of three women of color who were doctoral students in chemistry and neuroscience. Participants’ counterstories revealed doctoral programs that institutionalized oppression, exploited their identities, and dismissed their lived experiences, thereby, relegating them to outsiders-within academe. This marginalization precluded the crucial socialization of participants into their doctoral programs and ultimately disincentivized their pursuit of scientific careers. These findings encourage researchers to revise methodologies used to explore the problem of URSC higher attrition rates, compared to their white and Asian peers, from science doctorates.

Strand 12: Educational Technology
Poster Session B
4:15pm – 5:15pm, Riverside East

B136. Measuring Semantic Similarity in Written Text: Applications to Learning and Assessment
Jianfu Chen, Stony Brook Univerisity
Minsu Ha, Kangwon National University
Ross H. Nehm, SUNY Stony Brook
ABSTRACT:
Few studies in the field of science education have focused on computational methods for analyzing the similarities and differences in text-based responses using natural language processing and computational linguistics. We introduce semantic similarity techniques that can be used to measure text similarity. We ask: (1) Can semantic similarity techniques be used as proxies for changes in student understanding? (2) Can semantic similarity techniques be used to detect differences in student reasoning across assessment items intended to measure the same construct? We applied three semantic similarity methods (using two types of word lists) to the analysis of two large text corpora. In line with predictions, for corpus 1, all six semantic similarity indices between a pair of items in the post-course corpus were significantly and meaningfully higher than those in the pre-tests, in line with independent human scoring that also showed significant increases in understanding. Also in line with predictions, for corpus 2, the six semantic similarity indices among three items were significantly higher in a learning context found to be more difficult (loss) than an a more well-understood context (gain). Our results suggest that semantic similarity methods may offer unique insights in text-rich studies.

B138. Does Displaying the Real-time Voting Results affect Students' Conceptual Learning Outcomes in Clicker-integrated Science Classrooms?
Yu-Ta Chien, National Taiwan Normal University
Chun-Yen Chang, National Taiwan Normal University
ABSTRACT:
This study explores the relationship between high school students' conceptual learning outcomes of Newton's laws of motion, and the use of a prominent feature of clicker systems, i.e., the display of real-time class responses aggregated by clickers. With a controlled experiment and the instructional design that is widely used in clicker-integrated science instruction, this study demonstrates preliminary evidence that displaying the real-time responses of the whole class can inhibit students' conceptual learning. The effect sizes obtained in this study reach medium to large magnitudes. The current study serves a warrant that science teachers should rethink whether displaying the real-time responses of the whole class is needed in clicker-integrated science classrooms.

B140. Is it Real? Students' and Teachers' Perceived Perceptions of Virtual Presence during a Remote Microscopy Investigation
Gina Childers, North Carolina State University
M. Gail Jones, North Carolina State University
ABSTRACT:
Remote access technologies enable students to investigate science by utilizing scientific tools and communicating in real-time with scientists and researchers with only a computer and an Internet connection. Very little is known about how realistic remote investigations are and how immersed the students are in the experience. This study, conducted with high school students (n = 72) and their teachers (n =3), explored the impact of students' perception of ownership and virtual presence during a remote investigation using a scanning electron microscope. Students were randomly assigned to one of two treatment groups: students able to select

their own insect to use during the remote investigation, and students that did not select their own insects to view during the remote investigation. The results of this study showed that students' in the experimental group reported being more present (less distracted) during the remote investigation than students in the control group, whereas students in the control group reported controlling the technology was easier than the experimental group. Students indicated the remote investigation was very real; however, the teachers of these students were less likely to describe the investigation as being real. Issues of ownership and virtual presence in remote investigations are discussed.

B142. Facebook Platform for Learning Chemistry and for Developing Teachers' TPCK

Ron Blonder, Weizmann Institute of Science
Shelley Rap, Weizmann Institute of Science

ABSTRACT:
Web 2.0 is a term referring to the second generation of internet services. As a social network, Facebook is part of Web 2.0 and allows different types of uses for teaching and learning. Facebook facilitates group interactions between students and teachers and between student peers. The research objectives are to examine whether and how chemistry Facebook groups can be used by high-school teachers, and to examine the changes that the teachers have undergone throughout the year concerning the characteristics of the Facebook group, the teacher's role and the learning that took place within the group. Two case studies will present the analysis of the self-efficacy, attitudes, and TPCK of two teachers that used a chemistry Facebook group with their students. We identified the importance of using social networks in the field of chemistry teachers' professional development. Teachers have to be life-long learners in order to become professional chemistry teachers who are able to use technology to enhance chemistry learning.

B144. Assessment Item "Cover Stories", Semantic Similarity, and Successful Computerized Scoring of Open-ended Text

Minsu Ha, Kangwon National University
Ross H. Nehm, SUNY Stony Brook

ABSTRACT:
One of the major tasks for 21st century science education is to develop assessment tools that align with authentic scientific practices. Applications of computer science methods to science assessment have grown in recent years and demonstrated promising findings. This proposal explores the impact of assessment item "cover stories" on automated computerized scoring of open-ended text responses, and examines how semantic similarity analyses may be used to predict when these "cover stories" will cause problems for these systems. We collected and scored 3807 written answers in response to three new science assessment items. We used three measures (kappa, precision, recall) to quantify the correspondence between human and computer scores. We calculated a semantic similarity index and examined associations with between semantic similarity and computer scoring success. We found that semantic similarity was significantly correlated to scoring success for many concepts (variation, limited resources, differential survival, need/goal, use/disuse, and adapt/acclimation). The 'type of selection' significantly impacted scoring model kappas for the concepts of variation, differential survival, need/goal, and use/disuse while other item features did not shown any significant effects. This study illustrates how semantic similarity analyses can help to predict when "cover stories" will impact scoring efficacy.

B146. Designing Learning Games with Augmented Reality: Science Student Teachers' Learning Outcomes

Miri Barak, Technion, Israel Institute of Technology
Shadi Asakle, Technion- Israel Institute of Technology

ABSTRACT:

The goal of this study was twofold: to introduce the learning game design methodology for science education, and to examine the way student teachers create games empowered by augmented reality (AR). This study was conducted in the settings of a four-week workshop on 'learning games design', among 68 student teachers. The mixed method research was employed for analyzing the participants' learning games, their reflections about the learning process, and their final grades. Findings indicated statistically significant correlations between student teachers' ability to define the game rational and learning objectives and their ability to outline the gameplay and thinking skills. Female participants indicated a better ability to incorporate thinking skills in the game design and create a game that is easy to play. However, male participants were better at creating logical connections between the scientific concepts. The qualitative analysis of student teachers' reflections indicated a change in the way they manage and present their learning materials. They had to activate cognitive operations in a way that was new to them by connecting scientific topics to everyday life and by applying the game design methodology while using AR.

B148. Investigation the Effects of Computer Assisted 5E Learning Approach on the Instruction of Cell Division and Reproduction

Yilmaz Kara, Karadeniz Technical University

ABSTRACT:

This study was conducted to investigate the effects of computer assisted 5E learning approach for the instruction of cell division and reproduction unit in terms of biology curriculum. A pretest–posttest control group included quasi experimental design was adopted. The sample consisted of 57 students (aged 16 to 18 years) from one high school. Among the classes of the 10th graders, one of the classes was assigned as the experimental group (n=28) the other one was assigned as the control group (n=29). The students of the experimental group were taught through the computer-assisted instruction, whereas the comparison group students received constructivist instruction. In order to compare the differences between control group and experimental groups in terms of the objectives the t-test was applied to the data obtained through the instruments of the study. As a result, the comparison group activities were more effective than the computer-assisted 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.

Strand 13: History, Philosophy, and Sociology of Science

Poster Session B

4:15pm – 5:15pm, Riverside East

B150. Student Attitudes toward Biotechnology: Deconstructing a Construct to Develop a Comprehensive Instrument

Grant E. Gardner, Middle Tennessee State University
Angelique Troelstrup, Middle Tennessee State University

ABSTRACT:

This work examines current scholarship on the measurement of student attitudes toward biotechnology by reviewing 38 empirical studies published between 1990 and 2011. The analysis was motivated by a lack of coherence in the theoretical conceptualization attitudes toward biotechnology in the current literature. In order to provide a theoretical and empirical synthesis we analyzed all the items used to measure attitudes toward biotechnology in these 38 studies. 512 items were analyzed, reduced, and utilized to created an instrument that was piloted on a sample (n = 98) of post-secondary biology majors students. Factor analytics resulted in a five factor solution that was then utilized to build a theoretical construct to synthesize this disparate body of literature.

B152. Inquiry and Valuing in Science Education based on John Dewey's Perspective

Eun Ah Lee, University of Texas at Dallas

ABSTRACT:
Inquiry has been emphasized in science education and it is expected to help students make an informed decision for science-related issues. Previous studies implied, however, that students may not use inquiry-based evidences in decision making for science-related issues. Decision making requires value judgment. Nevertheless, how inquiry can help value judgment in science education has not been much explored. In this study, the relationship among scientific inquiry, value judgment, and decision making was explored based on John Dewey's perspective. Dewey viewed that science education is to develop students' ability to inquire and scientific inquiry can contribute to value judgment and decision making. According to Dewey, inquiry and values are not separated but related because the direction taken by inquiry is under the influence of values. As scientific inquiry is active human activity of knowing, valuing is active human activity to make value judgment. Thus, scientific inquiry cannot be conducted without valuing. By adopting Dewey's perspective, we can help students experience scientific inquiry and valuing in science education, and further in making an informed decision for science-related issues.

Strand 14: Environmental Education
Poster Session B
4:15pm – 5:15pm, Riverside East

B154. Primary Education Teachers' Management of Inner Contradictions in the Building of an Agroecological Learning Environment

Arnau Amat, Universitat de Vic - Universitat Central de Catalunya
Mariona Espinet, Universitat Autònoma de Barcelona, Catalonia, Spain

ABSTRACT:
School food gardens, understood as agroecological learning environments, sometimes are difficult to manage by teachers all over the world. This paper offers a contribution within science as well as environmental education by presenting a case on primary education teachers' management of school food garden from a socio-cultural perspective. In this case, teachers built a school food garden, in order to involve different community stakeholders in the everyday school activities. Through an ethnographical approach, different inner contradictions were described and were grouped in three dialectical tensions: agency | structure, sense | reference and individual | collective. In addition, from a time progression perspective, it was possible to identify three critical moments, each one dominated by a particular tension.

B156. H2Oklahoma: Valuable Learning or Costly Play?

Julie A. Thomas, University of Nebraska
Nicole Colston, Oklahoma State University

ABSTRACT:
In this study, researchers hypothesized the H2Oklahoma Water Festival, a one-day field experience, would positively impact students' science content knowledge and environmental worldviews. Researchers employed a pre/post-test evaluation method wherein fifth graders (n=101) completed a 15 question survey before and after participating in 25 small-group activities led by community partners and state agencies. Results point to significant improvement in both students' science content and environmental worldview scales. Contributions introduce (1) new understanding about the cost/benefit value of outdoor learning, (2) the potential of science diagrams as a measure of learning progressions, and (3) continued reflection on the New Ecological Paradigm (NEP) Scale for Children (Manoli, Johnson, and Dunlap (2007).

B158. Value Beyond the Standards: A Case Study of a Prairie Restoration Environmental Education Project
Teresa J. Shume, Minnesota State University Moorhead
ABSTRACT:
This qualitative case study sought to describe the pedagogical value of a tall grass prairie restoration project integrated into third grade curriculum. Students participated in field trips in fall and spring to study tall grass prairie at a regional science center. Native prairie plant seeds were collected in fall, grown in classrooms, and transplanted in spring. Further, prairie-related science lessons were taught during the academic year. Focusing on seven teacher-participants, data sources included field trip observations, classroom science lesson observations, teacher interviews, and artifacts such as curricular materials. Ongoing thematic analysis ultimately resulted in a principal assertion that the pedagogical value of the prairie restoration project and its related curriculum both included and exceeded learning outcomes described in state science standards. In particular, this environmental education project served as a scaffolding for cross-disciplinary curriculum integration, supported the development of scientific thinking, offered powerful life experience for children, and made abstract concepts more accessible through concrete connections. This study, resulting in seven recommendations for science teacher educators, demonstrated that an environmental education project can not only address several state science standards, but can offer valuable pedagogical outcomes beyond ones typically captured in state science standards.

B160. Teaching Environmental Sustainability Using a Place-based Watershed Modeling Application
Nanette I. Marcum-Dietrich, Millersville University
ABSTRACT:
This study explores whether the Model My Watershed (MMW) curricula has an impact on students' conceptions of the watersheds, their ability to apply watershed content learned to real-world problems, and investigates the misconceptions about the watershed that persist after instruction. MMW (NSF DRL ITEST #0929639) is a visually engaging, free, web-based application that invites students to explore and evaluate the condition of their local watershed using real-data and a scientifically valid watershed model. A full scale study of the MMW curriculum was conducted in sixteen classrooms with approximately four hundred secondary students. While statistically significant learning gains were measured, most students failed to reach the highest levels of watershed understanding as defined by Gunkel et al. (2012). Further refinement of the MMW curricula is needed to help students trace water among many pathways, to be able to predict the likelihood that water will follow one pathway over another and to trace the connections among groundwater, surface water and atmospheric water vapor.

Strand 15: Policy
Poster Session B
4:15pm – 5:15pm, Riverside East

B162. Operationalizing Metrics of Persistence and On-Track in the STEM Pipeline Using the National Clearinghouse Database
Eric N. Wiebe, North Carolina State University
Landon LaPorte, North Carolina State University
ABSTRACT:
Modeling persistence has been an important tool used by STEM researchers and policy-makers. However, most of the work done to date has been applied to modeling with databases and research questions working at large scale. Of equal interest would be how to use a model of persistence to ask questions about the efficacy of a single outreach group. For that reason, the research presented here addresses the following questions: 1) How

can we define and operationalize persistence so that it can be used as a metric to help assess the efficacy of STEM pipeline intervention programs? and 2) How can national educational databases be leveraged to provide localized (rather than nationally or regionally aggregated) persistence analysis on the efficacy of a small number of programs? In addressing these questions, two metrics were operationalized for purposes of analysis: persistence and on-track. Results using a sample of students from university STEM outreach programs show similar characteristics based on these two metrics. This modeling exercise points to a number of challenges and limitations working with this data set, but also reveals the potential power of such metrics to help inform outreach programs as to their impact on the STEM pipeline challenge.

Plenary Session #2

Science Teacher Education in an Era of Science Education Reform: A Global Perspective

8:30am – 10:00pm, Grand Ballroom CD South, EF

Presider:

Valarie Akerson, Indiana University

Discussants:

Norman Lederman, Illinois Institute of Technology, Editor of Journal of Science Teacher Education

Judith Lederman, Illinois Institute of Technology, Editor of Journal of Science Teacher Education

NOTE: First author listed will be presenter for group.

Presenters:

Africa

Meshach Ogunniyi, University of the Western Cape, South Africa

Marissa Rollnick, University of Witwatersrand, Johannesburg, South Africa

Asia

Liu Enshan, Beijing Normal University, China

Liu Chang, Beijing Normal University, China

Jian Wang, Beijing Normal University, China

Australia

David Treagust, Curtin University, Australia

Jacinta Petersen, Notre Dame University, Australia

Mihye Won, Curtin University, Australia

Georgie Wynne, Catholic Education Office of Western Australia, Australia

Europe

Justin Dillon, University of Bristol, United Kingdom

Virginie Albe, Ecole Normale Supérieure de Cachan, France

Maria Evagorou, University of Nicosia, Cyprus

Jouni Viiri, University of Jyväskylä, Finland

North America

Joanne Olson, Iowa State University, USA

Todd Milford, University of Victoria, Canada

Chris Ohana, Western Washington University, USA

Christine Tippett, University of Ottawa, Canada

South America

Hernan Cofre, Pontifica Universidad Catolica de Valparaiso, Chile

Germán Ahumada, Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile

Johanna Camacho, Universidad de Chile, Santiago, Chile

Melina Furman, Universidad de San Andrés, Buenos Aires, Argentina

Rómulo Gallego, Universidad Pedagógica Nacional de Bogotá, Colombia

Corina González-Weil, Pontificia Universidad Católica de Valparaíso, Valparaíso, Chile

David Santibáñez, Universidad Católica Silva Henríquez, Santiago, Chile

Royman Pérez, Universidad Pedagógica Nacional de Bogotá, Colombia

María E. Podesta, Universidad de San Andrés, Buenos Aires, Argentina

Claudia Vergara, Universidad Alberto Hurtado, Santiago, Chile

ABSTRACT:

There are currently global concerns about the quality of science education. The specific concerns driving our displeasure with the quality of science teaching and learning are economics, national security, and a general desire to promote scientific literacy among the citizenry. As a consequence, many nations have developed reforms (in the form of new standards) to our approaches to science teaching, curriculum, and assessment.

These reforms have obvious implications for teacher education; in particular how an individual is "licensed" to be a classroom teacher of science. The presentations in this session will summarize articles published in a special issue of the *Journal of Science Teacher Education* titled, "Preservice Science Teacher Preparation: A Global Perspective."

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

Equity and Ethics Committee Sponsored Session
Symposium - Jhumki Basu Scholars Symposium: Curriculum, Assessment, and Learning Environments to Enhance Science Teaching and Learning
10:30am - 12:00pm, Columbus EF
Presenters:
Devarati Bhattacharya, University of Minnesota, Minneapolis
Ying-Chih Chen, Arizona State University
Helen Douglass, University of Colorado, Denver
Tam'ra-Kay Francis, University of Tennessee, Knoxville
Brittany A. Garvin, University of South Carolina College of Education
Amal Ibourk, Michigan State University
Shiyu Liu, The Pennsylvania State University
Kathryn A. Stofer, University of Florida
Ibrahim H. Yeter, Texas Tech University
ABSTRACT:
Join the 2014 Basu scholars in this interactive poster session as they share their exciting and compelling research that spans many areas of science education, including teacher education, teacher professional development, instructional practice, science identity, and science content. 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.

Membership and Election Committee Sponsored Session
Admin Symposium - The Future of NARST Leadership: YOU
10:30am - 12:00pm, Columbus GH
Presenters:
Pauline W.U. Chinn, University of Hawaii at Manoa
Lynn A. Bryan, Purdue University
ABSTRACT:
Interested in becoming involved in NARST leadership? Curious about what positions are available and what the responsibilities are? In this interactive session, a panel of current and former NARST leaders will present the importance of broad and active membership participation in NARST leadership. There will be a brief overview of the election process, with timeline and nomination materials and a brief description of the responsibilities of each position. Panel members will present their perspectives of their roles and highlight the professional benefits of serving NARST, e.g., developing professional relationship with science educators around the world; providing rewarding professional service to our field, and contributing to the shaping of local, national, and international policies in our field. There will be time for questions and for interacting with various members of the current and past NARST Executive Board.

Strand 1: Science Learning, Understanding and Conceptual Change
Toward a More Comprehensive Theory of Modeling Instruction
10:30am - 12:00pm, Grand A
Presider: David F. Treagust, Curtin University

Benchmark Lessons: Integrating Modeling with Games for Learning Physics
Kara Krinks, Vanderbilt University
Pratim Sengupta, Vanderbilt University
Douglas B. Clark, Vanderbilt University
ABSTRACT:
Modeling is widely regarded as the language of science and a core disciplinary practice in the development of scientific expertise. Additionally, digital games for learning offer a promising medium for fostering expertise in science learning environments. Our goal is to investigate how the integration of modeling and graphing as core gaming activities can support students' conceptual development in Newtonian physics. We present two pedagogical approaches in which modeling is integrated into games through benchmark lessons. Using an explanatory case study approach, we examine students' learning processes during these lessons and identify elements of curriculum and game design that are essential to the successful integration of modeling into game environments.

Students' Views of Model Evaluation and Change of Models In Different Science Context
Silvia Wen-Yu Lee, National Changhua University of Education
Hsin-Kai Wu, National Taiwan Normal University
Hsin-Yi Chang, National Kaohsiung Normal University
ABSTRACT:
This study aimed to understand students' views of the nature of model evaluation and the nature of change of models in different context. A total of 102 eighth graders and 87 eleventh graders were surveyed. Two cases, the SARS and dinosaur extinction, were presented to prompt students' ideas about different models proposed by scientists. The statistical results showed different context of the model influenced how the students viewed model evaluation and model change. The students' answers also showed significantly differences between the high school level and the middle school level for their views of model change. The common reasons behind students' choice were related to students' understanding of the changeable nature of model and the science process. The students who chose that "one model is better than another" tended to justify their response by their understanding of the content. Interestingly, some students' views of the dinosaur extinction model were guided by their beliefs that information about the dinosaurs is unfathomable. The findings suggest that researchers should be aware that the models chosen for teaching and for assessment can interact with other factors, such as their familiarity of the content, their level of education and understanding of the nature of science.

Mismatches between Represented Science Content and Unmet Expectations as a Mechanism of Model Revision
Lauren Barth-Cohen, University of Miami
Michael C. Wittmann, University of Maine
ABSTRACT:
Models and modeling are a growing topic in science education. We focus on one of the sub-processes of modeling: model revision. The process of model revision is typically underdefined in specially designed modeling curricula. There are many ways to conceptualize model revision, but here we focus on model revision due to mismatches between the science content represented in a model and unmet expectations about that same model. Drawing on the knowledge-in–pieces theoretical framework, we present five cases of such model

revision in the context of 9th graders modeling the steady state energy of the Earth using an embodied modeling instructional activity. These mismatches led students to modify both the conceptual content and how it was represented in their model. This mechanism for model revision may be applicable to model revision in other classroom instruction settings.

Fostering Meta-Modeling Knowledge in Consideration of Domain-Specific Knowledge
Anja Czeskleba, University of Duisburg-Essen - Biology Education
Philipp Schmiemann, University of Duisburg-Essen - Biology Education
ABSTRACT:
Models and modeling are integral parts of learning scientific inquiry. Without models science is neither learnable nor teachable. A fundamental requirement for an elaborated understanding of scientific modeling is the knowledge of the nature of models and modeling (meta-modeling knowledge, MMK). Therefore, the learning of MMK is viewed as a separate learning goal and has to be fostered equally in science class. Moreover, empirical evidence indicates that successfully problem solving, and modeling, depends on domain-specific knowledge. In our study we investigated how MMK could be fostered in an optimal way – in consideration of domain-specific knowledge. Therefore, 320 students (average age 10 years) learned with different worked-out example tasks. In respect of MMK content, the tasks were identical. The only difference between the groups was the point in time when domain specific information was imparted, respectively if there was any information about the domain content included. Analysis indicates that the learning success in MMK does not depend on weather they have domain-knowledge, or not. However, the point in time of giving domain-specific information is a determining factor for successful learning of MMK. In conclusion, fostering simultaneously seems to be the best choice for students to learn MMK and content knowledge.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Representations, Models and Reasoning
10:30am - 12:00pm, Water Tower
Presider: Folashade Afolabi, Tshwane University of Technology, Pretoria South Africa

Information Processing from different Representations in Biology – Students' Abilities and Strategies
Kathrin Ziepprecht, University of Kassel
Julia Schwanewedel, Leibniz
Jürgen Mayer, University of Kassel
ABSTRACT:
This paper reports a quantitative study about learners' representational abilities and strategies in the domain of biology. Comprehension of texts, pictures and text-picture-combinations can be described according to the integrated model of text and picture comprehension (Schnotz & Bannert, 2003). Strategies are differentiated into cognitive (rehearsal, organisation, elaboration) and metacognitive (monitoring, regulation) strategies (Brown, 1984; Flavell, Miller, & Miller, 1993). We aim to empirically describe learners' representational abilities and to detect patterns of strategies students apply to representations in biology classes. In addition the relationships between certain strategy-patterns and learners' abilities are investigated. The methodological approach involved a task-based test on students' abilities to process information from texts, pictures and text-picture combinations (57 items) and a closed questionnaire on strategies (25 items). 968 9th- and 10th graders from different schools in Germany have answered both instruments. Data analysis was based on probabilistic and classical test theory. We found that the abilities needed to process information from texts can be statistically separated from the abilities needed to process pictures and text-picture-combinations and that students apply mixed strategy patterns (metacognitive and cognitive strategies). There are positive relationships between metacognitive strategies in combination with cognitive rehearsal strategies and representational abilities.

Design Heuristics to Enable Students Productive Use of Evidence in K-12 Classrooms

Katherine L. Mcneill, Boston College
Leema Berland, University of Wisconsin-Madison

ABSTRACT:
Although recent reform documents and standards place evidence as a central component of scientific practice, it is discussed and used in vague and inconsistent ways throughout the literature. The range of uses of the term "evidence" means that students could be doing a wide range of activities when they work with evidence. We therefore argue that the vague and contradictory uses of the term "evidence" causes confusion on the parts of students, teachers, and researchers. In this paper, we examine the literature in science studies and the philosophy of science to develop an understanding of the sensemaking work of science. Next, we turn to research in science education to inform our thinking about how students engage in this work. Combining these literature bases, we identify and illustrate 3 design heuristics to guide educators and researchers in supporting students as they use evidence to engage in the scientific practices. In particular, we argue that, in order to effectively transform classroom practice and enable students to engage in scientific sensemaking they must have access to evidence that is: close to nature, transformable, and taken-as-shared.

Evaluating a Science Claim versus Making Decisions: Effect of Goals on High School Students' Requests for Evidential and Explanatory Information

Jacqueline Wong, UCLA
William A. Sandoval, University of California, Los Angeles

ABSTRACT:
Evidence and explanatory mechanism are central to knowledge construction in science. In school, we typically engage students with using evidence and mechanism toward goals of constructing or evaluating knowledge claims. As we continue this effort, it is also important to understand how a shift to the goals of everyday scenarios would affect people's use of evidence and mechanism. While people often encounter science claims in the course of personal and societal decision-making, few are explicitly engaged in the production of science knowledge. Goals have a strong influence on reasoning. In this paper, we examine the extent high school students request information about evidence and mechanism as they engage in a claim evaluation goal versus decision-making goals.

Children's Engineering Design: More than Mere Science

Mijung Kim, University of Alberta
Wolff-Michael Roth, University of Victoria

ABSTRACT:
In science classrooms, engineering technology is often understood and practiced as a way of explaining or applying scientific knowledge in designing and building. However, given that technologies such as construction, brewing, and metallurgy were present in human history long before the arrival of anything that might plausibly be called modern science, it is not correct to assume that technology is merely applied science. In modern society where science and technology are intermingled in complex ways, the presence of technology is not a simple dimension of science at all. From this perspective, engineering technology in classrooms can be taught not as merely the application of science but as a unique form of cognition and tradition with its own interactive relations to problem solving and knowledge development. In this study, we attempt to understand how science and engineering are taught and practiced in children's problem solving tasks in Grade 2-3 science classrooms. Descriptive and explanatory case study is employed as a research method. We analyze children's engineering through three stages of problem solving: (a) goal sharing, (b) designing and doing, and (c) reflecting on solution. Through the video analysis, we discuss how children's engineering is dis/connected to science knowledge and curriculum.

Examining Student Collaboration and Knowledge Building Through the Use of A Synchronous, Tablet-Based Science App

Carrie-Anne Sherwood, University of Michigan

ABSTRACT:
Students are increasingly expected to learn science through engagement in science practices (NGSS Lead States, 2013; NRC, 2012). Because collaboration and the use of technology are fundamental parts of the work of science, participating in authentic science in schools, as described in current reform documents, requires that students engage collaboratively, and use technology in scientifically similar ways. Though calls for the integration of technologies in schools are ubiquitous, and more technology-based instructional tools are introduced into classrooms every day, the question arises whether digital mobile technologies and apps enable students to engage in collaborative knowledge building in the scientifically authentic ways described in the reform documents. This study examined the construct of student collaboration to investigate how collaborative learning, within the context of a tablet-based app, facilitates knowledge building among pairs of sixth-grade students. By providing detailed cases of diverse learners as they engage synchronously in a mobile app-based science learning environment within their traditional science classroom, we address calls for research to better understand the role of collaboration in technology-rich classrooms. More specifically, our study articulates how students participate in knowledge building through collaborative discourse within a technology-facilitated science-as-practice environment, that exists within a naturalistic setting.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Instructional Approaches and Student Outcomes
10:30am - 12:00pm, Grand Suite 5
Presider: Irene U. Osisioma, California State University, Dominguez Hills

Teaching Physics in Our High School Classrooms

Dennis W Sunal, University of Alabama
Cynthia Szymanski Sunal, University of Alabama
John Dantzler, University of Alabama
Donna P. Turner, University of Alabama
James W. Harrell, University of Alabama
Mogan D. Aggawal, Alabama A&M University
Marilyn Stephens, University of Alabama

ABSTRACT:
What is happening in our science classrooms? The purpose of this study was to determine common teaching practices occurring in physics classrooms among a large representative sample group of schools and teachers from a diverse, geographically large population. Critical variables addressed were physics teacher preparation, teaching performance, and impact of these two variables on students from a statewide population. An adaptation of a convergent parallel design was utilized in this descriptive study. Three separate parallel studies were conducted to answer the overarching research question, What is the nature of the secondary physics classroom in our high schools as it exists today?

Exploring the Impacts of Interaction with Indigenous Craftsmen on Senior Secondary School Students' Achievement in Physics

Irene U. Osisioma, California State University, Dominguez Hills
Peter A. Okebukola, Lagos State University, Nigeria
Hakeem Akintoye, Lagos State University, Nigeria

Grace Njoku, Lagos State University, Nigeria
Solomon Aragbede, Lagos State University, Nigeria
Yinka Orulebaja, Lagos State University, Nigeria

ABSTRACT:
The current study explored the impact on physics achievement of Senior Secondary School students' interactions with indigenous local craftsmen. Physics students undertook a trip to local indigenous workshops located in close proximity to their schools, and interacted with the craftsmen who worked at these workshops. The premise for the study was on the belief that the most natural learning is achieved through personal experience as individuals interact with the world around them, acquires new information without the constraints of the classroom environment. Mixed-methods approach to data collection and analysis within a quasi-experimental non-randomized pre-test, post-test, non-equivalent control group design was used. Data were obtained from one hundred and seventy-eight students and three physics teachers using a test of physics achievement, semi-structured interviews of teachers and students and observation of workshops and classrooms. Results showed that the physics achievement of experimental students improved significantly and surpassed those of the control group. Both teachers and experimental students expressed the desire to continue to use the strategy for subsequent teaching and learning. Results of the study provided added support for the use of out of school strategies in science instruction.

The Potential of Ambitious Instruction for Fostering Science for All: A Comparative Case Study

Anna M. Strimaitis, Florida State University
Sherry A. Southerland, Florida State University
Jonathon Grooms, Florida State University
Patrick J. Enderle, Florida State University
Victor D. Sampson, Florida State University

ABSTRACT:
This study explores what students from different achievement groups learn over the course of an academic year at two different schools. At school A, students experienced chemistry laboratory instruction through traditional, verification investigations. At school B, students experienced ambitious chemistry laboratory instruction engaging them in a wide variety of scientific practices. All students completed a chemistry content knowledge assessment, a performance task assessment, and scientific writing assessment at the beginning and end of the school year. For analysis purposes, students were assigned to low or high achievement groups based on their pre-test score on each assessment. Within each achievement group, paired-samples t tests for each assessment were used to document learning gains. Differences between mean achievement group scores at each school were analyzed using an independent samples t test. The achievement gaps narrowed on the performance task and scientific writing assessment between lower performing students and their higher performing peers when students were engaged in ambitious instruction at school B, a pattern not seen at school A. These findings suggest that all students are capable of becoming more proficient in science when engaged in ambitious instructional practices.

Cognitive Activation in Biology Lessons

Christian Förtsch, LMU Munich
Sonja Werner, LMU Munich
Lena von Kotzebue, LMU Munich
Birgit Jana Neuhaus, LMU Munich

ABSTRACT:
According to constructivism, students have to be cognitive active to foster conceptual understanding. Cognitive activating lessons combine different effective features of instructional quality, which engage students to think on a higher level, and therefore fosters students' understanding of the content and achievement. Educational

research mainly describes three key features: cognitive level of students' activities, conceptual instruction and thoughtful discourse. This part of the DFG-funded project LerNT focusses on measuring cognitive activation in biology lessons and its influence on students' situational interest and achievement. Therefore, 28 German biology teachers have been videotaped for three botany lessons and a rating manual for cognitive activation was adapted for the subject biology. Additionally students completed a questionnaire on their situational interest after each lesson and participated on a standardized knowledge test. Multilevel models showed a significant influence of cognitive activation on students' achievement (β=.19, p<.10) and students' situational interest (β=.23, p<.01) when controlled for intrinsic motivation and interest in biology. Despite of some limitations due to the small sample size we could show that cognitive activation in biology lessons can be measured objectively, reliably and validly. Based on our results we consider it important to include cognitive activation in biology teacher education and training.

Lack of Physics Teachers

Isaac Buabeng, University of Canterbury
Lindsey Conner, University of Canterbury
David Winter, University of Canterbury

ABSTRACT:
In this study, we were interested in how approaches to teaching high school physics in New Zealand influenced students' perceptions of physics and their consequent desire to continue with physics. We also investigated the reasons participants became physics teachers to inform how more teachers might be attracted into the profession. The convergent parallel design of this study used mixed methods including a national survey as well as classroom observations and interviews with teachers and students. The study has identified how a focus on content knowledge and more "traditional" teaching approaches tends to discourage students to progress with physics.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Socio-scientific Issues in Science Education
10:30am - 12:00pm, Grand Suite 3
Presider: Wardell Anthony Powell, Polk County Public Schools

Data Explorations in Ecology: Students' Understanding of Variability and Use of Data in Environmental Citizenship

Alan R. Berkowitz, Cary Institute of Ecosystem Studies
Cornelia Harris, Cary Institute of Ecosystem Studies
Tobias Irish, Cary Institute of Ecosystem Studies

ABSTRACT:
What are the benefits from and requisite supports for students to do data-based inquiry and critique using combinations of first hand and second hand data? High school teachers, scientists and education researchers working together in the Data Exploration in Ecology Project (DEEP) explored this question with modules in biology and environmental science classrooms. Multiple sources of data about student learning and teachers' practices revealed positive outcomes from the data exploration activities, and from making a framework of inquiry and critique practices explicit in professional development.

Enhancing Korean Middle School Students' 21st Century Skills through Collective Intelligence based SSI Instruction

Yunhee Choi, Soongmoon Middel School, Seoul, South Korea
Yeonjoo Ko, Ewha Womans University

Hyunju Lee, Ewha Womans University

ABSTRACT:
Our assumption of the study is that SSI instruction is an effective tools to promote knowledge and skills that students must master as future citizens. And in the context of SSIs, the concept of Collective Intelligence facilitates their learning. Thus, we designed and implemented SSI lesson plans over 12 weeks and observed the effects of the program on enhancing students' communication, collaboration, critical thinking, and information management skills. Twenty 9th grade students voluntarily participated in the extra-science program. Data was collected by administering a questionnaire before and after the program and conducting classroom observations and focus group interviews with students. The results indicated some degree of improvement in their targeted skills. First, they tried to make efforts to be more flexible to different points of views in making necessary compromises in order to accomplish a common goal. Second, they seemed to feel more comfortable in using oral, written and nonverbal communication skills to articulate and express their own opinions. Third, they seemed to feel somewhat confident in effectively analyzing and evaluating scientific evidence, arguments, claims and beliefs. Lastly, they seemed to feel more confident in collecting valid information efficiently and effectively and in managing the flow of information.

The Derivation of an Instructional Model and Design Processes for Socioscientific Issues-based Teaching

Troy D. Sadler, University of Missouri
Patricia J. Friedrichsen, University of Missouri-Columbia
Kerri Graham, Rock Bridge High School

ABSTRACT:
Ample theoretical and empirical evidence has been offered in the science education literature in support of socioscientific issues (SSI) based teaching, but this work has not been sufficiently translated into tools that are understandable and usable by teachers. Additionally, a key challenge for today's teachers is navigating new expectations for science learning called for in the Next Generation Science Standards (NGSS). This project addresses gaps between theory/research and practice relative to SSI-based teaching aligned with the NGSS through a case study of the design and implementation of a SSI unit for high school biology. We share results of the design and implementation case study including evidence of student learning of science content knowledge (as measured through pre/post-intervention assessments) and a SSI instructional model and design process. The instructional model provides guidelines for the use of issues to frame instruction; integration of science ideas, scientific practices, social considerations and information communication technologies; and application of a culminating experience. The planning and design process presents eight steps for SSI-based teaching aligned with NGSS. Both the SSI instructional model and the design process make available practical resources to guide teachers and curriculum designers as well as move SSI research toward more coherent applications.

The Relationship Between Moral Sensitivity and SSI Reasoning

Eunhang Lee, Ewha Womans University
Dana L. Zeidler, University of South Florida
Younglan Chung, Ewha Womans University

ABSTRACT:
This study examines how students' moral sensitivity, as revealed in a socioscientific issues (SSI) study unit, affected Korean students' SSI reasoning. A ten-hour classroom SSI program for high school students was developed and implemented early in the school year. Two hundred and two high school juniors completed a worksheet comprising various questions designed to evaluate moral sensitivity and SSI reasoning. Qualitative analysis of the students' written data revealed four moral sensitivity characteristics in the SSI class: student recognition of a situation's moral aspects, awareness and empathy for how possible resolutions may affect other people, anticipation of possible societal consequences, and evaluation of the various perspectives encompassing a situation. The analysis also revealed three aspects of SSI reasoning: complexity, perspectives, and inquiry.

Students' moral sensitivity and SSI reasoning were scored, and the relationship between moral sensitivity and SSI reasoning was examined using regression analysis, which revealed a statistically significant relationship. Ten students were randomly selected for in-depth interviews; their transcripts were analyzed using the four moral sensitivity characteristics and three aspects of SSI reasoning. A positive correlation was observed between improvement in moral sensitivity and SSI reasoning, suggesting that moral sensitivity plays an important role in SSI classes and in students' SSI reasoning.

Impact of Emotive Reasoning on Students' Integration of Scientific Considerations on Decision- Making about Socioscientific Issues

Wardell Anthony Powell, University of South Florida

ABSTRACT:

The purpose of this investigation was to design, implement, and evaluate a four-week integrated socioscientific issues (SSI) high school biology curriculum that was aimed at understanding the relationship between students' emotive reasoning and their decision- making on SSI. An instrument developed by (Zeidler et al., 2013) that required students to imagine they served on a public review committee to help create guidelines and policy for how a transplant program should operate was used. Forty-five 9th grade students from two Biology Honors classes at a Tampa Bay Area High School participated in this study. Results show that students used emotions such as sympathy and empathy to influence their decisions on SSI. Students also used probability of the surgery being a success, overall health of the patient, compatibility of the organ to be transplanted to the patient's body, and the age of the patient who would receive the transplant as scientific considerations to influence their decisions regarding how to rank order the patients for the heart transplant. The findings from this investigation highlight the need for science teachers to ensure that their classrooms are places where students are given opportunities to engage in practices to enhance their ability to evaluate evidence and make informed decisions.

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

Engineering Education

10:30am - 12:00pm, Roosevelt

Presider: Miri Barak, Technion, Israel Institute of Technology

Designing for Retention of Engineers with Curriculum Reform in General Chemistry

Kent J. Crippen, University of Florida
Treavor H. Boyer, University of Florida
Chang-Yu Wu, University of Florida
Philip J. Brucat, University of Florida
Maria Korolev, University of Florida
Trisha de Torres, University of Florida
Marykay Orgill, University of Nevada, Las Vegas

ABSTRACT:

ChANgE Chem is a design-based research project to transform the curriculum of undergraduate general chemistry to a more contextually relevant and engaging experience for engineering students. ChANgE Chem uses specific design elements to target the retention of underrepresented students. Grounded in cognitive apprenticeship, the reformed curriculum situates water, air, waste and energy as fundamental principles in practical engineering problems, communicated as human-interest design projects. The projects are instructed through a sequence of scaffolded model-eliciting activities during the recitation portion of the course. This paper presents the results of a mixed methods field trial with second semester general chemistry. The study focuses on determining if students learned chemistry, if their self-efficacy was impacted, and to assess their perception of the intervention. Results indicate significant learning gains for all students, but no changes in self-

efficacy. All students felt that the approach was successful, but the target population demonstrated a stronger positive response about the authenticity of the experience. The results are described in terms of revisions prior to a pending pilot study. This paper will be of particular interest to researchers using design-based research to address traditionally difficult problems in science education through the research and development of transformative learning environments.

Comparison of Intended Engineering Majors at 2-and 4-year Institutions: Backgrounds, High School Experiences, and Goals
Allison F. Godwin, Purdue University
Geoff Potvin, Florida International University
Zahra Hazari, Florida International University
Leidy Klotz, Clemson University
ABSTRACT:
In the U.S., much attention has been paid to the dearth of STEM graduates, especially engineering graduates. Simultaneously, student enrollment at 2-year post-secondary institutions (those institutions that do not award 4-year bachelor's degrees but award large numbers of certificates and Associate's degrees) has increased dramatically, including amongst students intended on STEM/STEM-related careers. Various social and economic factors have been cited; however, the factors that may influence students to choose engineering careers in college continue to be poorly understood. We begin to address this issue using nationally representative student survey data of likely engineering majors enrolled at both 2- and 4-year institutions by providing a comparison in terms of their backgrounds, high school mathematics and science experiences, and their career goals and aspirations. Results indicate that likely engineering students at 2-year institutions have lower prior academic performance; are less likely to be of Caucasian or Asian descent; are less likely to have taken chemistry or physics in high school; and show some differences in attitudes towards engineering and career expectations than their 4-year counterparts. Conversely, such students are remarkably similar in many high school science and mathematics experiences suggesting they may succeed in engineering careers if they are afforded the opportunities.

Novel Makerspace Internship: How Culture Supports Engineering Student Creativity and Initiative
Thomas R. Tretter, University of Louisville
Stephanie B. Philipp, Miami University
Cindy Harnett, University of Louisville
ABSTRACT:
Engineering education is supposed to prepare students for a productive career spanning decades. However, the fast pace of technology means a student's own laptop can become nearly obsolete during the four or five-year path through college. Engineering students must know how to identify new problems and find new resources to solve them. During their training, students need to encounter the unexpected and exercise their creativity, and a unique venue to explore as a possibility for supporting these types of student experiences is a community makerspace, a type of engineering and craft workshop organized, equipped, and operated by interested community volunteers. We connected a local makerspace with an engineering school's internship program to integrate more intensive student-driven projects into the undergraduate engineering curriculum. Using ethnographic research techniques to capture and synthesize the impact of the experience on students from both an outsider and an insider perspective, results show that students strengthened their ability to tackle ill-structured problems, acquired a heightened sense of what day-to-day engineering work might include, and strongly enhanced skills and dispositions to engage in creative problem-identification as well as problem-solving.

Graduate Engineers Teaching Authentic Science in Secondary Science Classrooms

Jaclyn K. Murray, University of Georgia
Barbara A. Crawford, University of Georgia

ABSTRACT:
In what ways do engineering doctoral fellows advance and/or impede reform-based teaching practices in secondary science? The aim of this investigation is to explore the experiences of graduate students who plan to teach at the university level, and to examine their enactment of reformed-based teaching practices. So, why examine this issue? The answer to this question is two-fold. First, post-secondary teaching practices are rarely reform-based, relying heavily on lecture due to lack of time attributed to faculty research responsibilities. In the future, these engineering doctoral fellows will likely teach undergraduate courses. An understanding of reform-based practices could empower fellows to be thoughtful about selecting appropriate learning opportunities in their own practice. Secondly, science educators, untrained in the field of engineering, are baffled by the addition of the engineering practices contained within the Next Generation Science Standards (NGSS). Knowledge of how engineers execute design tasks could inform the application of engineering activities at the K-12 level. Cases, represented with thick description, articulate the experiences of three doctoral engineering fellows teaching secondary science. Three themes collectively link each case: student learning, communication, and science and engineering practices.

Instructor Goals and Practices Related to STSE (Science, Technology, Society and the Environment) in the Teaching of Undergraduate Engineering Students

Lisa Romkey, University of Toronto

ABSTRACT:
Engineering undergraduate programs are expected to explore the relationship between technology and society, encourage action on critical social issues, and consider the impact of engineering on society – the hallmarks of STSE (Science, Technology, Society and the Environment) education. The goal of this research was to explore instructor teaching goals and practices, and more specifically their goals and practices related to the use of science, technology, society and the environment perspectives in their own teaching of undergraduate engineering students. This study employed an online survey at four universities in Canada, designed to provide an initial understanding of STSE in the context of engineering education, followed by a set of in-depth interviews. The results demonstrated that: 1) Engineering instructors demonstrate a very diverse set of teaching goals and practices; 2) Engineering instructors believe STSE is relevant to the engineering curriculum, although there is variance between the different components of STSE; and 3) The challenges and enabling factors are significant, and similar to those found in the K-12 teaching community. More broadly, this study provides a novel bridge between theory and practice in the K-12 and university/college sectors, and will perhaps lay a pathway for further partnerships and inquiries in STEM education.

Strand 6: Science Learning in Informal Contexts

Informal Science Experiences of Young Children and Families

10:30am - 12:00pm, Comiskey

Presider: Josephine Desouza, Ball State University

"The Map Don't Help": Disadvantaged Families Experiences of Visiting A Science Museum

Emily Dawson, King's College London
Louise Archer, King's College London
Billy Wong, University of Roehampton
Amy Seakins, King' College London
Jennifer Dewitt, King's College London

ABSTRACT:

Informal science learning environments (ISLEs) such as museums and science centres have been found to provide valuable opportunities for people to engage with and learn about science. The exploratory qualitative case-study reported here forms part of a five-year, mixed-methods study working with 21 schools and four science museums across the UK, which aims to help students and their families find science engaging, interesting and useful for improving their life chances. The part of the study reported here focuses on five families from one of the 21 schools in the first year of the project and sought to explore in detail the ISLE experiences of families from that school. The families' ISLE visits were explored using focus groups and interviews with students, interviews with parents and observations of families during their museum visits to examine whether they were able to enjoy, engage with or learn science through their visits. Despite describing their visits in positive terms as 'fun' and 'exciting', four of the five the families involved in this study struggled to derive science learning from their science museum visit or to develop science capital. These findings suggest ISLEs may be less inclusive than they are sometimes hoped to be.

A Kids'-Eye View of Interest in the Zoo

Alexandra M. Burris, Indiana University
Adam V. Maltese, Indiana University

ABSTRACT:

The goal of this ongoing research is to find and assess the ways that zoos function in the creation of environments for triggering and nurturing interest in animals, conservation, and science. The experiences of children in such institutions may be important because the development of interest is often considered an important prerequisite for the decision to pursue a career in science (Tai et al, 2007; Maltese & Tai, 2010). This study piloted two techniques which may allow researchers to capture the experience of visitors as it is actually occurring. First, an interactive survey was created and refined which contained a major portion meant to be filled out during the duration of the visit. The second method takes this idea one step further by piloting the use of personal video cameras worn by children throughout their zoo visit. The use of this technology could provide researchers with qualitative data surrounding the experiences of children visitors during the real time of their zoo visit. Current and subsequent results of the study continue to shed light on the role of animal behavior, interactives, signage, repeat visitation, and family discussion in the development of interest among child zoo visitors.

Parent Chaperone-Student Interactions during a Field Trip to an Informal Science Education Camp

Kelly A. Riedinger, David Heil & Associates, Inc.
Amy R. Taylor, University of North Carolina Wilmington

ABSTRACT:

In this paper, we explored interactions between parent chaperones and students during a school field trip to an informal science education camp. This project was motivated by a gap in the research on learning conversations--though there are a wealth of studies in the literature exploring how parents engage children from their own families in sense-making practices, still lacking are studies exploring how adults interact with other children. Our analysis used sociocultural learning theories and parent-child interactions frameworks to understand the ways in which parent chaperones talk with students during school field trips. We collected data from groups attending a marine science field station for a three-day field trip and videotaped learning conversations that took place during science activities. Findings suggested that like families, parent chaperone-student groups used epistemic resources to make sense of science content and took on a variety of social roles during interactions. However, parent chaperones took on new and different roles when engaging with students who were not their children. The findings from this study further elaborate on research related to parent-child learning conversations while also contributing to our knowledge of field trips in informal science education settings.

Preschool-Age Children Engaged in Science Practices through Astronomy Experiences at a Museum
Julia Plummer, Pennsylvania State University
ABSTRACT:
This exploratory study begins to address how informal science venues can provide opportunities for preschool-aged children to engage in sense-making practices, specifically constructing explanations based on evidence. Data was gathered during a series of workshops on astronomy at a children's science museum. Findings support recommendations of the NSTA position statement for Early Childhood (2014) by showing that children are capable of engaging in scientific practices, demonstrating the important role adults play in helping children learn science, showing that young children develop science skills in informal settings, and pointing to the importance of experiential learning for young children. Findings also point to features of museum programs that support young children. First, children needed an opportunity with the phenomenon in order to have an opportunity to gather evidence to make a claim, such as through first-hand experiences, photographs, and models to engage children with astronomical phenomena. Second, children engaged in making claims based on evidence when an educator engaged them with scientific questions. Third, children's engagement in constructing explanations goes beyond just verbal responses to an educator. Children drew heavily on the affordances offered by materials at hand as well as their own gestures to help them communicate their explanations.

Strand 8: In-service Science Teacher Education
Related Paper Set - Testing the Consensus Model of Effective PD: Analysis of Practice and the PD Research Terrain
10:30am - 12:00pm, Grand B
Presider and Discussant: Hilda Borko, Stanford University
ABSTRACT:
NGSS puts extra pressure on the need for knowledge about models of professional development (PD) that support high-quality science teaching and learning. While researchers have proposed a consensus model of effective PD (Desimone et al, 2009), few studies examine this model empirically and fewer still look at impact on student learning. Also missing from PD research are lines of research that study PD programs in increasingly rigorous ways over time as mapped out in Borko's seminal paper (2004) calling for more systematic PD research. This paper set reports on a rich line of research about an analysis-of-practice PD program that addresses these research gaps. This research tests the consensus PD model by exploring impact on teacher content knowledge, teacher PCK, teaching practice, and student learning via quasi-experimental and experimental studies. The line of research also explores aspects of all three phases of Borko's PD research terrain and pushes beyond these boundaries to examine impact when analysis-of-practice program features are implemented in online, preservice, and district-wide contexts that test the scalability and sustainability of the PD approach. Each paper examines how one aspect of this research expands the consensus model of effective PD and/or Borko's terrain of needed PD research.

Testing the Consensus Model of Effective PD: A Videocase-based, Analysis-of-Practice Program
Kathleen J. Roth, California State Polytechnic University, Pomona
Nicole I. Z. Wickler, California State Polytechnic University, Pomona

*Science Teachers Learning from Lesson Analysis (STeLLA): An RCT Study Comparing Analysis-of-Practice PD and Content Deepening PD*Joseph A. Taylor, BSCS
Christopher Wilson, BSCS
Kathleen J. Roth, Cal Poly Pomona Foundation

*Findings from the STeLLA Line of Research Expand the Consensus Model of Effective PD*Connie Hvidsten, BSCS
Jody Bintz, BSCS
Paul Numehahl, BSCS
Kathleen J. Roth, Cal Poly Pomona Foundation

Inititial Development and Testing of a Videocase-based, Analysis-of-Practice Program
Kathleen J. Roth, Cal Poly Pomona Foundation
Nicole I. Z. Wickler, California State Polytechnic University
Expanding the STeLLA Professional Development Terrain: Testing Scalability and Sustainability Betty Stennett, BSCS
Christopher Wilson, BSCS
Susan M. Kowalski, BSCS
Nicole I. Z. Wickler, California State Polytechnic University
Kathleen J. Roth, Cal Poly Pomona Foundation

Strand 10: Curriculum, Evaluation, and Assessment
Engineering
10:30am - 12:00pm, Columbus AB
Presider: Shannon H. Sung, Spelman College

Learning Science through an Engineering Curriculum
Selcen Guzey, Purdue University
Tamara J. Moore, Purdue University
Gillian Roehrig, University of Minnesota
Michael Harwell, University of Minnesota
Alison Phillips, Research Assistant
Mario Moreno, Research Assistant
ABSTRACT:
This study examines the influence of integrated STEM (science, technology, engineering, and mathematics) curriculum units on students' learning about science and engineering. The study is based on results from a large scale National Science Foundation, Mathematics and Science Partnership project whose purpose is to increase student learning of STEM concepts in Grades 4 - 8 using an integrative engineering design-based approach to teacher professional development and curricular development. Preliminary findings show mixed results of the effectiveness of integrated STEM curriculum units on student learning of science and engineering. Regression analysis and HLM will provide further insights into the effects of integrated STEM education on student achievement.

Scalable Approaches to Modeling and Engineering in High School Biology
Kathy Lea Malone, The Ohio State University
Anita Schuchardt, University of Pittsburgh
Christian D. Schunn, University of Pittsburgh
ABSTRACT:
The NRC framework for science education and the NGSS have created a need for additional research on and development of curricula that involve both modern modeling tools and engineering practices. This is especially the case for biology education, which traditionally include neither. We describe a quasi-experimental design study to test the effectiveness of model-based instruction focused on the concepts of natural selection and

population ecology that makes use of Excel modeling tools (MBI-E). The overarching storyline of the 4-week curriculum unit revolves around an engineering design task of controlling an invasive species. Diverse model-based activities are woven throughout the unit, beginning with storyboards and data tables, and gradually moving to graphs and equations in Excel. The study takes place in the Midwest within ten high schools teaching regular level introductory biology classes, with implementing teachers and matched schools using traditional instruction. A post-test was designed that targeted a number of common misconceptions in natural selection and population ecology. The results of a post-test demonstrate that the MBI-E students significantly outperformed the traditional classes in both natural selection and population ecology concepts, thus overcoming a number of misconceptions.

Student-Oriented Meta-Assessment in a Project-Based Systems Engineering Course
Niva Wengrowicz, Technion
Yehudit Judy Dori, MIT
Dov Dori, Technion
ABSTRACT:
Project-based learning (PBL) fosters meaningful learning especially in science and engineering courses. However, it poses assessing difficulty, since instructors usually assess the quality of the project and assign the same grade to all the team. Peer assessment and student-oriented meta-assessment—assessment of the quality of students' peer-assessment— were used to incorporate an individual assessemnt dimansion. Our research goals were to develop and implement a pedagogical method for teaching PBL courses and to develop, test, and validate a student-oriented meta-assessment tool for assessing each student's learning outcomes. The population comprised of 131 undergraduate students who studied a systems and information engineering course in a PBL environment. The students constructed conceptual models of complex Web-based systems using two approaches and languages: Object Process Methodology (OPM) and Unified Modeling Language (UML). The teaching team assessed students individually based on the quality of arguments presented and the thinking levels students demonstrated in their peer assessment. We found a significant difference between the meta-assessment grades of students who reported higher-than-average involvement in their team project and those who reported lower-than-average involvement level. The meta-assessment approach extends peer assessment in project-based learning courses and enables differentiating between the performance of the team and the individual.

An Engineering and Science Framework for Teaching K12 Bioenergy Concepts: A Delphi Consensus Study
Brian Hartman, Oregon State University
Kimi Grzyb, Oregon State University
Katharine G. Field, Oregon State University
ABSTRACT:
This study develops an engineering and science framework for teaching bioenergy in K12 settings. Socio-scientific issues, such as energy production, provide a way to situate student learning in real-to-life contexts. Understanding alternate energy sources is a way to engage students in a larger societal debate. Because bioenergy intersects the biological, chemical, and physical science/engineering domains, it represents a unique opportunity to integrate disciplines that operate largely independently. Educators and researchers from the bioenergy community were recruited to participate on an expert panel that was charged to develop a consensus on the essential bioenergy concepts for K12 students. The Delphi methodology was used to elicit bioenergy concepts from the experts, develop a consensus, and prioritize the concepts for learning. The resulting bioenergy education framework will allow K12 teachers to focus on essential bioenergy concepts and will be a framework for future research in alternative energy education.

Teaching Basic Nanotechnology Concepts in the Context of Nanotechnology Applications: Results of a Delphi Study

Ron Blonder, The Weizmann Institute of Science
Sohair Sakhnini, The Weizmann Institute of Science

ABSTRACT:
The goals of the current study are to map applications of nanotechnology that are recommended to be taught in school science, and to find the "need-to-know" nanotechnology concepts for each of the selected nanotechnology applications. We will present our attempt to address these goals based on a Delphi study of the exert community. Five nanotechnology applications that should be taught in high school and at the undergraduate level were found to be important and reached a consensus by the Delphi study experts: (1) nanomedicine; (2) nanoelectronics; (3) nanosensors; (4) nanobots; and (5) self-cleaning. Mapping the applications of nanotechnology that should be taught in high-school science and finding the connections between the applications and the essential nanotechnology concepts constitutes an important step that supports designing a context-based nanotechnology program before it is integrated into the high-school science curriculum.

Strand 11: Cultural, Social, and Gender Issues
Language and Linguistics
10:30am - 12:00pm, Columbus KL
Presider: Muhammad Abd Hadi Bunyamin, University of Minnesota

Next Generation Science Learning for English Language Learners: Identifying Some Dilemmas of Practice

Savitha Moorthy, SRI International
Angela H. DeBarger, SRI International
Yves Beauvineau, Culturally Responsive Science Pedagogies

ABSTRACT:
This paper reports on the lessons learned from a research-practice partnership focused on the science learning of English Language Learners (ELLs) in the context of new approaches to science education (e.g., the Framework and the Next Generation Science Standards [NGSS]). Grounded in an approach to research and development called Design-Based Implementation Research (DBIR), the objective of this paper is to describe how contextual factors and current patterns of science instruction influence the science learning experiences of ELLs; the dilemmas of practice they present for the equitable implementation of the NGSS; and the implications of the findings for cultivating research-practice partnerships. By investigating a national challenge—of supporting the science learning of ELLs—in the context of a specific school district, this paper illustrates the early stages of a research-practice partnership and provides insight into issues other researchers seeking to pursue a DBIR approach and establish meaningful collaborations with practitioners will need to consider early on.

STEM Against All Odds: Cases of Access, Opportunity, and Persistence Among Recently Arrived, Low-Income, Urban Immigrant English Language Learners

Jeremy Heyman, Columbia University
Christopher Emdin, Columbia University

ABSTRACT:
This investigation employs a critical ethnographic case study approach to explore the paths of twelve urban immigrant young adult English language learners from developing countries who are pursuing Science, Technology, Engineering, and Mathematics (STEM) careers. Beyond documenting the academic trajectories and issues faced by each student from arrival in the United States as an older teen or young adult through high school and the first two years of college, a longer discussion opens of lessons to be gleaned from these young

people's backgrounds, influences, and experiences, especially those of their unique high school experience and their post-secondary experiences. High school and college science and math coursework and a variety of STEM enrichment and outreach programs, including early research experiences, as well as advising and mentoring relationships, are among the pieces that will be considered by the study. Analyzing commonalities and emergent themes behind these remarkably successful and resilient students' experiences, against a backdrop of social and cultural capital theory as well as resilience and persistence frameworks, may provide novel insights into future work in increasing access and persistence in STEM amongst populations facing multiple barriers to entry and success.

Science: A Mechanism for Making Classroom Discourse Accessible to Emerging Bilinguals
Enrique Suarez, University of Colorado, Boulder
Valerie K. Otero, University of Colorado, Boulder
ABSTRACT:
Despite extensive research and national reports that call for students' engagement in scientific practices, these strategies continue to be virtually absent in classrooms throughout the U.S. Thus, the question of how students who are learning English as a second language fare in these environments is virtually unanswered. Understanding these students' engagement in science activities is becoming increasingly critical, as the NGSS get implemented throughout the U.S. This study presents results from an investigation on 1st grade emerging bilingual students participating in engineering design, and 3rd grade emerging bilingual students' participation in a physics lesson on sound production. We focus on the changes in participation as such changes pertain to scientific practices of argumentation, modeling, and experiential, imaginative, and mechanistic reasoning strategies. Drawing from students' discourse and gestures, conjectures are made about scientific practices being particularly well suited for fostering productive disciplinary engagement for emerging bilingual students.

Supporting Science Learning in Linguistically Diverse Classrooms using Multimodal Tasks: An Exploratory Study
Preetha K. Menon, UC Santa Cruz
ABSTRACT:
My study explores the potential of multimodal tasks - visual drawing tasks - to support the science learning of students from linguistically diverse backgrounds during the teaching of an unit in photosynthesis. Data collected and analyzed include student interviews, students' self-efficacy scores on surveys and rubric scores of students' visual drawing tasks representing their understanding of photosynthesis on four constructs of science and language learning namely use of symbols, use of images, use of curriculum-based terms and disciplinary core ideas. The students were categorized based on their English proficiency and Vocabulary acquisition scores on state tests. Initial analysis reveals that the differences were statistically significant for Use of Symbols between English Learner group and Re-designated group ($t = 2.72$, $p = .01$), Use of Symbols between English Learner group and English only group ($t = 2.58$, $p = .01$), for Use of Symbols ($t = 3.47$, $p = .001$), Use of Images ($t = 2.06$,$p = .04$), Use of Core Ideas ($t = 2.27$, $p = .02$) between those who scored between 53%-83% in vocabulary acquisition and those who scored more than 84%. The findings hold promising evidence of the integrated use of symbols, images and disciplinary core ideas to support science and language learning of students.

Strand 12: Educational Technology
Educational Technology in the Secondary and Post Secondary Environment
10:30am - 12:00pm, Gold Coast
Presider: Michael S. Tutwiler, Harvard

Technology Use in Post-Secondary STEM Courses: Findings and Implications from a Meta-Analysis

Rana M. Tamim, Zayed University
Eugene Borokhovski, Concordia University
Robert M. Bernard, Concordia University
Richard F. Schmid, Concordia University

ABSTRACT:
The current paper builds on the results of a large meta-analysis (MA), which addressed instructional technologies' on students' achievement and attitude outcomes (Authors, 2014). The overall MA synthesized effect sizes from 674 studies investigating technology use in postsecondary contexts from 1990 up to 2010. The synthesis of 879 achievement outcomes resulted in an average effect size of 0.27 with moderator analyses indicating that cognitive support tools were more effective than presentation and delivery tools. The present systematic review focuses on the subset of studies that addresses technology use in STEM (Science, Technology, Engineering, Mathematics) disciplines. The total number of included effect sizes was 353 resulting in an average effect size of 0.27, which is in agreement with the findings from the original MA. Results also supported the importance of cognitive tools and the consistency of technology's effect on students' achievement in all four STEM disciplines. The presentation will provide an overview of the original MA and its findings as well as the STEM specific one. In addition, exemplars of technology use will be presented and implications for instructional practice will be discussed.

Physics Students' Social Media Learning Behaviours and Connectedness

Rachel Moll, Vancouver Island University
Wendy Nielsen, University of Wollongong
Cedric Linder, Uppsala University

ABSTRACT:
This paper reports on a study which aimed to examine secondary and post-secondary physics students' social media learning behaviours through focus group interviews and used complexity thinking as a conceptual framework (Davis & Sumara, 2006) to characterize students' learning behaviours for the potential to lead to connectedness – the ability to benefit from being connected (i.e., learning). Focus group interviews were conducted with secondary (n=24) and post-secondary (n=10) physics students. Social media resources that students mentioned were tallied and the ways students used them were characterized for their potential to promote connectedness. Students named a wide variety of social media tools, but Facebook, videos, and online forums were used most frequently. Themes within these categories are discussed in detail in the paper. Results illustrate that students frequently access social media resources to support their learning, but that their social media learning behaviours are limited in their potential to promote connectedness.

Students' Learning Trajectories in Developing Explanatory Models: Exploring Adaptive Scaffolding of Interactions with Online Science Simulations

David E. Brown, University of Illinois Urbana-Champaign
Robb Lindgren, University of Illinois Urbana-Champaign

ABSTRACT:
In order to address issues with linear or non-adaptive framing of learning with simulations (e.g., a worksheet or linear sequence of web pages), in this research we explore the possibilities for embedding adaptive scaffolding with the simulation interface. To this end we explore a microanalytical focus on student learning with simulations designed to help students develop explanatory models of molecular processes. The goal of this research is to characterize the varied trajectories by which students develop appropriate explanatory narratives about processes involving unseen molecules and molecular motion and to identify effective pedagogical and technological supports for adaptively scaffolding student understanding of these processes. The cases discussed reveal some promising strategies for learning simulation designs that can be implemented as adaptive scaffolds, such as 1) modifying the simulation to better support identified issues with the construction of explanatory

narratives; 2) highlighting the links between simulation activity and data representations, and 3) prompting the student to consider the meaning of certain simulation characteristics and components. These findings present an actionable path with which to create and test modified simulation environments that have the potential to better support student construction of powerful explanatory models.

Learning Affordances related to Participation-in and Observation-of Particle Simulations: Hints from Seemingly Off-task Talk

Elon Langbeheim, Arizona State University
Sharona T. Levy, University of Haifa

ABSTRACT:
This study explores differences in students' explanations of heat conduction using the particulate model of matter. Two 9th grade classrooms were engaged in two modes of interaction with a simulation of a fluid. In one classroom, each student played the role of a particle and induced evaporation of the modeled fluid by colliding with its particles. In the other classroom, students watched the simulated process of fluid evaporation projected on the whiteboard as part of a teacher-led discussion of the evaporation and heat conduction mechanisms. The explanations of heat conduction and the descriptions of the state of the system during evaporation in each group differed in important ways. Drawing on student off-task conversations, we show that these differences can be explained according to features that caught students' attention in each mode of interaction with the simulation. Our findings highlight the opportunities for learning that are brought about by seemingly off-task activities in game-based learning environments.

Strand 13: History, Philosophy, and Sociology of Science
History and Philosophy of Science
10:30am - 12:00pm, Randolph
Presider: Michael R. Matthews, University of New South Wales

Eminent Scientists and Extended Peer Communities in a period of Post-normal Science

Dorothy V. Smith, La Trobe University
Pamela J. Mulhall, Monash University
Christina E. Hart, La Trobe University
Richard F. Gunstone, Monash University (retired)

ABSTRACT:
Research scientists who interact with sectors of the broader community do so in a variety of ways and for a variety of reasons. Some of these research scientists, by choice or by circumstance, develop a high public profile. We report on interviews with high profile scientists from varied fields of science and locations in Australia. These are individuals who provide a public face for science in Australia at a time when international and local controversy is threatening public perceptions of the relevance and authority of science. Our participants raised these controversies in their interviews as significant influences on their work. We report on the commitment of our participants to interaction with the public; the different ways in which they interact and their experience of the different needs of their different publics. We argue that these publics may be regarded as extended peer communities in post-normal science (Funtowicz & Ravetz, 2003). The work of these scientists foregrounds the need for science curricula to better acknowledge the changed context of research science.

Critical Contextual Empiricism and the Uptake of Change in Evolution Textbooks

Linda C. Fuselier, University of Louisville
Kasi Jackson, West Virginia University
Rachel Stoiko, West Virginia University

ABSTRACT:
We used the framework of critical contextual empiricism (CCE) to investigate how a scientific community incorporates critique of foundational ideas in introductory Evolutionary Biology textbooks. We used content analysis to examine sexual selection content in the three most commonly used undergraduate-level Evolution textbooks to determine if the texts reflect the critical analysis that has occurred in the field, primarily in the last three decades. We found that texts still employ anthropomorphic language but have almost entirely eliminated explicitly sexist and androcentric language. In two of the texts, authors acknowledge a shifting paradigm but social factors that are integral to this shift were not the focus of their explanations. We present excerpts from a time series analysis of the use of the classic paradigm in textbooks to show how uptake of critique is processed by a community of knowledge producers. Ultimately, the textbooks do not meet criteria for CCE because the science is still portrayed as separate from social influences. We discuss a case study on the incorporation of Bateman's work and provide suggestions for using this analysis to teach the nature of science and understanding of objectivity in college classes.

Physics Education Research and Mixed Methods Research Then and Now: Establishing a Symbiotic Relationship

Jonathan Engelman, University of Cincinnati
Lindsay Owens, University of Cincinnati

ABSTRACT:
From its inception through present day, physics education research (PER) has utilized mixed methods research (MMR) techniques, however, with little in-depth citing of the research literature from MMR. The research question for this paper is how can PER and MMR benefit each other through looking at how PER has used MMR? Our paper first reviews foundational studies in PER that used MMR techniques. Second, we examine how PER has used each of the three major MMR designs (concurrent, sequential exploratory, and sequential explanatory) in 34 studies published within the past five years. Finally, these observations are connected to current MMR methodlogy to establish a symbiotic relationship between PER and MMR. A majority of the articles do not include in-depth descriptions of their methodology, even though their described methods might be considered cutting edge by the field of MMR. IN looking to MMR for in-depth methodological rigor, PER can appeal to a wider audience within the educational research domain. In addition, MMR can add PER's methods to their own repertoire of recognized and endorsed research methods. This symbiotic relationship between PER and MMR can emerge if PER begins to describe its methodology in greater depth within their studies.

Ideology and Interdisciplinary Science Education Reform: An Althusserian Critique

Benjamin Allen, University of Tenneseee, Knoxville

ABSTRACT:
In recent years, a variety of publications have emerged from public, private, and academic entities concerning the development of interdisciplinary science education. Many of these public and private publications have defined the necessity of reforming science education in terms of socioeconomic impacts and have made recommendations for funding interdisciplinary programs at all levels of education. On the other hand, much of the current academic literature concerning interdisciplinary science education considers the subject from functionalist and administrative perspectives, aiming to contribute best practices for assessment, curricular programming, and scientific management of scientists and educators. In contrast to both of these efforts, this paper contributes a critical analysis of interdisciplinary science education reform by placing such efforts within the context of new ideological narratives of a changing global socioeconomic landscape. This interrogation is concerned with developing a critical understanding of the relationship that interdisciplinary science and science education have to ideology as a force of social reproduction, based in the theoretical contributions of the French Marxist philosopher Louis Althusser. The conclusions of this analysis advocate for critical, historical, and

materialist orientations in science education research, while emphasizing the role of ideology in social reproduction.

Strand 14: Environmental Education
Environmental Literacies
10:30am - 12:00pm, Grand D North
Presider: Dorene R. Medlin, Albany State University

Student and Pre-service Teacher Thinking about the Relationship between Ecology, Environmental Issues and Daily Life
Yael Wyner, City College of New York, CUNY
Erica Blatt, College of Staten Island, CUNY
Edita O'Brien, College of Staten Island, CUNY
Jessica Genter, City College of New York, CUNY
ABSTRACT:
This presentation describes an investigation of how secondary school students and pre-service teachers relate ecological concepts and environmental issues to their everyday lives. Four-hundred-six students completed written surveys and 64 students were interviewed. Additionally, 15 pre-service teachers completed surveys and were interviewed. The survey consisted of twelve open-ended questions that required diagrammatic and written responses. Interviews asked participants to explain their answers. The 12 items asked participants how the transportation they take, food they eat, energy they use, and plastic water bottles they use relate to the environment and environmental issues. Follow-up questions asked how food webs, and the water, carbon and nitrogen cycles relate to the transportation and the food they eat. Participants were able to discuss different ecological concepts and environmental issues at varying degrees of accuracy, but few participants were able to make personal connections or understand how their own behaviors in relation to food, transportation, energy, and plastic bottles are either impacted by or impact the environment. These results suggest the need for more explicit instruction at the secondary and post-secondary levels, in not only ecological concepts and environmental issues, but in helping students understand the personal ways they connect to these systems and issues.

Environmental-related Literacies Specified in the NGSS: Students' Attitudes, Knowledge and Concerns
Leslie Neitzer, Southern Illinois University
Vivien M. Chabalengula, University of Virginia
Frackson Mumba, university of Virginia
ABSTRACT:
This study assessed junior high school students’ attitude, knowledge and concerns towards environmental challenges stipulated in the new Next Generation Science Standards in the United States. Eighty-four students at a high school in the Midwestern USA, involving 48 females and 36 males participated. Results revealed that students were concerned and held positive attitudes toward environmental challenges, but their knowledge was limited; average knowledge score was 58.7%; students enrolled in ecology course and those from urban communities were more concerned about environmental challenges; a significant but weak and negative correlation existed between attitudes and knowledge; a non significant but positive correlation existed between attitudes and concerns; and no correlation was found between knowledge and concerns. The implications of these results to science teaching and learning are discussed. Key Words: attitudes, concerns, environmental literacy, junior high school, knowledge

A Comparison Study of the Environmental Literacy Plans in Tennessee and North Carolina

Karena M. Ruggiero, University of Tennessee
Barry W. Golden, University of Tennessee

ABSTRACT:
The research presented will provide a comparative look at the Environmental Literacy Plan's (ELP) of Tennessee and North Carolina through the lens of a decision matrix in order to determine the major points of difference between both state's plans, as well as explore the role of each state's political affiliation and socio-economic status in the development and implementation of environmental education. The presentation will focus of the decision matrix created to compare state's ELP in terms of political status, curriculum, professional development, amongst other criteria as defined by the North American Association for Environmental Education in ELP development guiding documents. The study is intended to be a pilot study prior to the start of a full fifty state Environmental Literacy Plan comprehensive comparison.

Encouraging Environmental Literacy in Elementary Classrooms: Challenges and Opportunities

Sarah J. Carrier, North Carolina State University
Kathryn T. Stevenson, North Carolina State University

ABSTRACT:
Although elementary school may be a prime stage for building environmental literacy (EL), elementary school teachers seem to face significant barriers to including EL in their instruction. Several studies have identified low content knowledge and heavy emphasis on state standards and testing as constraints to including more EL in elementary school classrooms. However, few of these studies have measured actual (versus perceived) environmental knowledge or focused on how teachers overcome the relatively static structural constraints of standards and testing. This exploratory study surveyed 627 randomly selected elementary school teachers in North Carolina to begin addressing this need. We measured teachers' environmental knowledge and asked about the largest barriers they perceive to including more EL, in what contexts they successfully teach EL concepts, and what types of support would further help them overcome constraints to teaching EL. We found environmental knowledge levels to be high. Respondents identified in-person, on-site professional development workshops; activities that integrate children's literature; and access to and training in published environmental education curricula as the resources needed to encourage the inclusion of EL concepts in the elementary school classroom.

Latent Path Model Assessing Relationship Between Epistemological Beliefs and Environmental Literacy

Gokhan Ozturk, Texas A&M University

ABSTRACT:
Human damage on environment and its effects on the planet is one of the hot topics discussed both in public and among scholars. However, human can reverse this damage or at least make situation sustainable. In this sense environmental literacy was explained as the goal of environmental literacy to make people literate about environmental problems. Research results revealed that environmental literacy is not linearly develop, on the contrary it is a sophisticated concept and epistemological beliefs can be one of the factors effecting it and our actions. In this study we tested this hypothesis by using structural equation model. According to the results our hypothesis testing the relationship between external and internal beliefs on environmental literacy had a good fit with data. Our findings suggest that epistemological beliefs have an effect and are predictors of environmental literacy.

Strand 15: Policy
STEM Schools in the NGSS Era: Components, Impacts, and Policy Implications
10:30am - 12:00pm, Columbus CD
Presider: Sharon J. Lynch, George Washington University

Critical Components of Inclusive STEM High Schools: Instrumental Variables Revisited, Rethought, and Re-envisioned

Sharon J. Lynch, George Washington University
Erin E. Peters-Burton, George Mason University
Tara Behrend, George Washington University
Edmund M. Han, George Washington University
Michael Ford, George Washington University
Nancy Spillane, George Washington University
Courteney Coyne, George Washington University
Ann House, SRI International

ABSTRACT:
This paper explores findings from a four-year research project on inclusive STEM-focused high schools (ISHSs) located across the U.S., using cross-case analyses of 8 instrumental case studies. The research began by developing a conceptual framework that hypothesized that 10 Critical Components would be found in "exemplar" ISHSs, but also allowed for emergent themes not among the Critical Components. The case studies provided evidence for the presence of all 10 Critical Components in 8 schools. However, 4 of 10 Critical Components were judged to be most prominent across the cases (STEM-focused curriculum; well-prepared teaching staff; administrative structure; and supports for students under-represented in STEM). Two additional themes emerged in all schools: positive STEM school climate, and an awareness of the connections to schooling and the world of STEM-related work. Although the Components and themes might be considered generic to any good school, they were enacted in ISHSs through their emphases on STEM disciplinary and interdisciplinary curriculum, instruction, and school climate, and are likely foundational to ISHSs that produce consistently positive outcomes for students under-represented in STEM fields.

Examining Inclusive STEM Schools' Role in College and Career Readiness of Students: A Multi-group Analysis

Niyazi Erdogan, Balikesir University
Carol L. Stuessy, Texas A&M University
Dane Bozeman, Texas A&M University

ABSTRACT:
Current perception for specialized STEM schools can be described as unique environments including advanced curriculum, expert teachers, and opportunities for internships and immersion. This study highlights the college readiness of STEM school graduates in comparison to traditional high school graduates. In answering the research questions related to success of students attending either STEM or traditional schools, we concluded success on reading, mathematics, science high-stake tests for students does not differ by school type. However, student demographic variables (i.e., gender, ethnicity, socioeconomic status, and special education status) may influence success of students attending STEM schools. For example, results revealed statistical significance between male, Hispanic, White, and economically disadvantaged students from STEM and traditional schools on reading, mathematics, and science scores.

Policy Implications from Social Network Typologies of STEM-Themed Urban Schools

Julianne A. Wenner, University of Connecticut
John Settlage, University of Connecticut

ABSTRACT:
This study arises from a broad project studying schools using systems perspectives in order to identify sources of science achievement gaps. Using social network analysis, we were investigated the types of social networks within K-8 schools that have a thematic focus on STEM learning, with the aim of informing science education policy. Data were collected from seven STEM-themed schools. Findings indicate that science networks are of

different types depending on the kinds of information being sought. For example, curriculum and content networks were often of similar density, but had drastically different measures of degree centralization. Additionally, the inside materials and outside resources networks were often much less dense, and had fewer leaders than the curriculum and content networks. These findings demonstrate that there are nuances in the organizational networks even within a single subject area in one school. We believe further investigations into the various science-related social networks within elementary schools have the potential to provide great insights into science education policy. A systemic view of schools is necessary in the creation of science education policy; only when we have a clear picture of the entire system can we make appropriate policy decisions concerning science education.

NGSS Implementation Resources: Averting Blind Spots
Zoubeida R. Dagher, University of Delaware
Sibel Erduran, University of Limerick
ABSTRACT:
In the current climate of marshaling resources to support the implementation of the Next Generation Science Standards (NGSS Lead States, 2013) in the USA, many state departments of education have begun the process of analyzing how their local standards compare to the new standards using resources developed for this purpose (e.g. EQuIP Rubric for Lessons and Units: Science; State Science Standards Comparison Tool). This process is a stepping-stone for developing curriculum materials that are aligned with the new performances expected of students in this new wave of reform. Against this backdrop, this paper voices concern that close attention to the standards proper are likely to focus on those listed in the main document and miss essential understandings that have been noted in supplemental documents. Focusing specifically on nature of science (NOS) understandings, this paper presents a framework and illustrates how it can be used as a NGSS resource for ensuring that the desired NOS understandings and performances are accounted for in curriculum materials and assessment tasks.

Concurrent Session #8
2:30pm – 4:00pm

Research Committee Sponsored Session
Symposium - CADASE Admin Session: Re-enacting Culturally Relevant Science Education: Lessons from the Chicago Grassroots Curriculum Taskforce Project
2:30pm - 4:00pm, Columbus IJ
Presiders:
Irene U. Osisioma, California;
Melody Russell, Auburn University,
Discussants:
Malcolm Butler, University of Central Florida
Neporcha Cone, Kenesaw State University
Obed Normal, Morgan State University
Femi Otulaja, University of the Witwatersrand, South Africa
Presenters:
Anton Miglietta, Chicago Grassroots Curriculum Taskforce
Cecily Relucio Hensler, Chicago Grassroots Curriculum Taskforce
Alejandra Frausto, Rudy Lozano Leadership Academy
ABSTRACT:
Science education has been reported to be effective only if it is situated within the context of students' life experiences and culture (Calabrese Barton, 2001). Practices that encourage students to bring their experiences

and emotional capital to science learning are fundamental if students are to become producers of science knowledge. As producers, relevancy is inherent in science learning because the environment for learning science is part of what is created (Fusco, 2001). This session involves a discussion of the work of Chicago Grassroots Curriculum Taskforce (CGCT) as a means of enacting culturally relevant science education. The CGCT develops grassroots structures, processes, programs tools, and models that allow educators to build their own curriculum from the ground up as they guide relevant, effective, and intentionally justice-centered content development with students and communities as co-creators. The session will serve to engage science educators in praxis-based dialogue that offers concrete avenues for the collective use of the grassroots curriculum across grade-levels, disciplines, and communities to promote culturally relevant science education. A critical unit of study from a high school science teacher is presented to provide the needed perspective for science education practitioners.

Strand 1: Science Learning, Understanding and Conceptual Change
Topics in Learning Progressions
2:30pm - 4:00pm, Columbus GH
Presider: Molly Bolger, University of Arizona

Quantitative Reasoning Learning Progressions in Environmental Science: Rasch Analysis and Student Learning
Jennifer H. Forrester, University of Wyoming
Robert L. Mayes, Georgia Southern University
Kent Rittschof, Georgia Southern University
Jennifer Christus, University of Wisconsin-Oshkosh
Franzi Peterson, University of Wyoming
ABSTRACT:
The ability of middle and high school students to reason quantitatively within the context of environmental science was investigated. A quantitative reasoning (QR) learning progression, with associated QR assessments in the content areas of biodiversity, water, and carbon, was developed based on three QR progress variables: quantification act, quantitative interpretation, and quantitative modeling. Diagnostic instruments were developed specifically for the progress variable quantitative interpretation (QI), each consisting of 96 Likert scale items. Each content version of the instrument focused on three scale levels (macro scale, micro scale, and landscape scale) and four elements of QI identified in prior research (trend, translation, prediction, and revision). The QI assessments were completed by 362, 6th to 12th grade students in three U.S. states. Rasch (1960/1980) measurement was used to determine item and person measures for the QI instruments, both to examine validity and reliability characteristics of the instrument administration and inform the evolution of the learning progression. Rasch methods allowed identification of several trends in student learning of QI and learning progression evolution.. Rasch diagnostics also indicated favorable levels of instrument reliability and appropriate targeting of item abilities to student abilities for the majority of participants.

Using a Learning Progression to Compare the Feedback Loop Reasoning of Elementary Students in the US and Lebanon
Hayat Hokayem, Texas Christian University
Hui Jin, Ohio State University
Sahar K. Alameh, University of Illinois Urbana Champagne
Hagop A. Yacoubian, Haigazian University
ABSTRACT:

Feedback loop reasoning is an important component of systems thinking. This study examined the extent to which elementary students used feedback loop reasoning to explain the change of predator prey populations in ecosystems. We conducted semi-structured clinical interviews with 44 students in the US and 34 students in Lebanon. All students were enrolled in grades 1 to 4. We used an iterative process to construct a learning progression of this reasoning across the two contexts, and ended up with seven levels. We used this learning progression to evaluate students' responses and compared the differences in reasoning between the students in the US and in Lebanon. We then discussed possible causes of the differences, which included the context of designing the learning progression and cultural differences.

Analyzing Effectiveness of Scaffolding to Promote Argumentation and Conceptual Understanding in an Electronic Science Notebook

Courtney Behrle, North Carolina State University
Eric N. Wiebe, North Carolina State University
Angela Shelton, North Carolina State University

ABSTRACT:
This research reports on a design study investigating scaffolds to support conceptual understanding through written argumentation coupled with inquiry investigations. Fourth-grade student work with a Magnetism unit was supported by an electronic science notebook, the CyberPad. Written responses to prompts in the CyberPad were analyzed for the quality of their argumentative claims, evidence, and scientific accuracy. In addition, this written work was compared to performance on a test of conceptual understanding taken at the end of the unit. Findings indicate students struggle to provide evidentiary content in their responses. In addition, there seems to be a lack of correlation between the quality of their scientific writing or argumentation and their conceptual test scores. Results will be used to refine the design of the CyberPad and recommended teacher support for future implementations.

Strand 1: Science Learning, Understanding and Conceptual Change
Using Representations for Teaching and Learning
2:30pm - 4:00pm, Gold Coast
Presider: Grady J. Venville, University of Western Australia

Sensing Science: Assessing K-2 Students Readiness for Reasoning with Kinetic Models of Heat

Carolyn Staudt, Concord Consortium
Elham Beheshti, Northwestern University
George Forman
Nathan Kimball, Concord Consortium
Jamie Broadhead

ABSTRACT:
In this paper, we present findings from our two-year study on the preconceptions young children (4 to 8 years old) hold in regards to the nature of temperature and heat and how their use of visual representations can improve their interpretation of temperature and heat. We use the word preconceptions to indicate the naïve ideas that children hold before formal instruction. Although thermodynamics does not appear in the science curriculum until middle school in the Next Generation Science Standards, our goal is to see if much younger children could explain concepts of temperature and heat. We hypothesize that the use of visualizations of heat concepts that emerge from interactions between the particles can serve as a better "tool for thinking" to help K-2 students better understand those concepts. Our findings suggest that, when aided by real-time visualizations, young children can use the kinetic heat model to disambiguate their current theories about temperature and heat.

Examining the Use of Multiple and Multimodal Representations on Students Science Knowledge Development and Retention

Heidi Wiebke, Indiana University
Meredith A. Park Rogers, Indiana University
Susan Hawkins, Indiana University
Jared R. Allen, Indiana University

ABSTRACT:
This study demonstrates how K-2 teachers incorporate multiple and multimodal representations during Properties of Matter lessons and how these representations support students' development and retention of the science content.

What Recent Research on Diagrams Suggests About Learning With Rather than Learning from Visual Representations

Christine D. Tippett, University of Ottawa
Larry Dean Yore, University of Victoria

ABSTRACT:
The move from learning science from talk, text, and other representations to learning science with talk, text, and other representations has many potential and un-documented complexities. This thematic analysis partially explores the established research foundation and trends of representational uses in science instruction by examining recent research on diagram use in science. 80 separate studies, published or presented between 2000 and 2014 (three 5-year periods between major science education reforms), were located through searches of databases and books. Open coding of these studies across the 15-year period identified dominant research approaches and 13 themes, 6 of which were identified in at least ten percent of the studies: eliciting mental models, classroom-based research, multimedia principles, teaching and learning strategies, representational competence, and student agency. The high proportion of studies indicated an emphasis on learning with rather than learning from representations and this trend increased across the three 5-year intervals considered. This shift mirrors a pedagogical shift from science instruction as transmission of information to interactive-constructivist approaches in which learners actively negotiate understanding and construct knowledge. A small proportion of studies explored the influence of prior knowledge on diagram use, suggesting that additional research is needed in this area.

Embodied Cognition as a Framework for Designing and Analysing External Representations to Teach Science

Kai Niebert, University of Zurich

ABSTRACT:
In search for fruitful learning activities the role of external representations came into the focus of science teachers and science education researchers. External representations cover a great range of learning activities like analogies, visualizations, diagrams, models, experiments etc. Using experimentalism as a theory of embodied cognition we show how this theory can serve as a framework to analyse and design external representations for science concepts of micro-, meso- or macrocosmic phenomena. The theory holds that all knowledge is embodied and thus experience based. Compared with objects and events in the mesocosm those of the micro- and macrocosm miss every-day accessibility, they are beyond our common world of experience, and only accessible with science and technology. We analysed external representations on cell division, neurobiology, the carbon cycle and the greenhouse effect in teaching experiments with 52 students. Based on this analysis we show how embodied cognition can inform the design of learning activities that lead learners to a deeper understanding. Based on our analyses we propose to distinguish external representations by the worlds of experience they refer to and furthermore by the learning activities' educational functions, i.e. affording experience, denoting conceptions, and reflecting embodied conceptions.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set - Material Practice and Materiality: Too Long Ignored in Science Education and Possibly the NGSS?
2:30pm - 4:00pm, Randolph
ABSTRACT:
In this paper set, international scholars explore the material in science and science education and its role in scientific practices that are key to curriculum focuses of science education programs in a number of countries. This five paper set discusses the importance of materiality and material culture and its application within various fields including feminist theory, history of science, elementary education and professional education to science learning. As a construct, culture can be understood as material and social practice. As fields of material social practice and worlds of meaning, cultures are contradictory, contested, and weakly bounded. The notion of culture as material social practices leads researchers to accept that material practice is as important as conceptual development (social practice), and thus science learning. In science education research, there has been is little interest in exploring how matter and machines (instruments) contribute to both ontology and epistemology in science and science education. Often material practice, such as those in the forms of scientific instruments, is ignored with instruments understood as "inscription devices", conduits for language rather than sources of material culture in which scientists share “material other than words” when they communicate new knowledge and realities (Baird, 2004, p. 7).

Using Spacetimemattering to Engage Science Education with Matter and Material Feminism
Kathryn Scantlebury, University of Delaware
Anita Hussenius, Uppsala University, Centre for Gender Research
Kristina Andersson, Centre for Gender Research, Uppsala University
Annica Gullberg, University of Gävle
Anna T. Danielsson, Uppsala University

The Materiality of Materials and Artefacts Used in Science Classrooms
Bronwen M. Cowie, University Of Waikato/WMIER
Kathrin Otrel-Cass, Aalbourg University

The Material Object and Patterns of Attention in Science Learning
Shirley A. Simon, University of London
Paul Davies, University of London

The Material Object and Patterns of Attention in Science Learning
David Heywood, Manchester Metropolitan University

The Materiality of Scientific Instruments and Why it Might Matter to Science Education
Catherine E. Milne, New York University

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Practices and Beliefs from Teachers inside the Classroom
2:30pm - 4:00pm, Columbus KL
Presider: Edward G. Lyon, Arizona State University

New Content, Strategies, and Tools, Oh My!: Preschool Teachers Navigate Innovations to Promote Science Learning

Marion Goldstein, EDC/Center for Children and Technology
Ximena Dominguez, SRI International
Regan Vidiksis, EDC/Center for Children and Technology
Ashley Lewis Presser, EDC/Center for Children and Technology
Danae Kamdar, SRI International
Christine Zanchi, WGBH Educational Foundation
Courtney Blackwell, Northwestern University

ABSTRACT:
This paper discusses findings from the early stages of a federally funded preschool science project that brings together a team of education researchers and educational media producers to develop, iteratively refine, and evaluate a science curricular program. The program integrates common classroom activities with digital learning experiences to promote young children's understanding of science concepts, engagement in science practices, and use of scientific discourse. While a growing body of research suggests that curricular resources that integrate technology can provide unique affordances to support science teaching and learning (Kallery et al., 2011; Penuel et al., 2011), supports to guide childhood educators as they integrate innovative resources into instruction are very much needed (Davidson, Fields, & Yang, 2009). Additionally, professional development supports are needed to enable teachers of young children to align instruction to changing conceptions of effective science education. In the study on which we report, preschool teachers implemented the program's first curricular module, focused on Life Science. We examined how they navigated challenges involving the use of new tools, content, and strategies, and identified areas where teachers need additional training to more effectively support children's learning of science content, practices, and discourse.

Examining the Relationship of Beginning Elementary Teachers' Beliefs and Practice

Sarah J. Carrier, North Carolina State University
Danielle DiFrancesca, North Carolina State University
Beth Greive, North Carolina State University

ABSTRACT:
This study examines the beliefs and practices of beginning teachers whose teacher preparation took place in a STEM focused program. The mixed methods used in this study compared measures of teachers' reform based and traditional science instruction beliefs using Teacher Beliefs about Effective Science Teaching survey (TBEST) to their enacted practice in their first year of teaching. Enacted practices were measured using teacher responses to the instructional goals section from science logs (Author, 2014). Interview data contribute to triangulation of data. Twenty five graduates from a STEM-focused teacher preparation program participated in semi structured interviews during their junior and senior years and again during their first year of teaching, completed science logs during their first year of teaching, and took TBEST. Data were compared looking for relationships between teachers' instructional goals and enacted practice and related to their beliefs about teaching science as documented using TBEST survey scores. Pearson's correlations were used to examine the relationship between the TBEST factors and the average high and low level instructional goals. There was a significant correlation between the second and third TBEST factors and compared with interviews that documented the impact of the teacher preparation program on their beliefs.

A Case Study on Science Teaching Practices and Teacher Perspectives in an Early Childhood Setting

Ayse Busra Ceviren, Istanbul Sabahattin Zaim University
Devrim Guven, Bogazici University

ABSTRACT:

The purpose of this descriptive case study was to describe science teaching practices and teacher's perspective on science education in an early childhood classroom and draw a picture of early childhood teachers' perspectives and practices at the setting on science education. Data were collected through lengthy observations at the early childhood classroom and in-depth interviews done with seven early childhood teachers. The data collected through observations, informal and semi-structured interviews, documents and field notes were coded in MAXQDA 11 and the themes of the study were constructed under two main themes: teacher practices and teacher perspectives. Teacher practices revealed that although engagement and conclusion periods of science activities were performed through active involvement of children, implementation periods involved considerable amount of teacher control. Demonstrations, explanations, authoritative question-answer session and video presentations were found to be the predominant strategies that result in teacher control. Teacher perspectives revealed three possible considerations for this situation: lack of understanding on science education, lack of understanding on importance and goals of science education, and lack of content knowledge on science. Finally, suggestions for pre-service and in-service teacher training programs were given.

Teacher Practices that Support Student Learning of Science Content and Practice

Joi Merritt, Arizona State University

ABSTRACT:

Research indicates that genetics is a difficult concept for students to learn. The Why do plants of the same species vary in how they look? web-based unit takes the approach of building students' ideas through the use of models and development of scientific explanation. The purpose of this case study is to identify instructional practices that a teacher engages in to support student learning. One teacher and his Grade 5 classes (ages 10-11) in a Michigan school district from the 2012-2013 and 2013-2014 were the focus of the study. A total of 167 students participated in this study over the two years. Data sources include pre- and posttests, a teacher survey, and video recordings of classroom enactment. Results from this case study identify instructional practices that seem to support student development of integrated understandings of abstract science content.

Voices from the Classroom: Elementary Teachers Talk about their Science Related Instructional Choices

Elisebeth Boyer, Ohio State University

ABSTRACT:

Time allocated for science instruction at the elementary level has decreased significantly in the past decade. Data was collected through a voluntary response survey using the online tool SurveyMonkey®. 43% of respondents said they taught science multiple times per week but analysis of data indicated that how respondents' identified science instruction did not typically align with how the NGSS defined science instruction. Indicating that the amount of time allocated to science instruction in the elementary school may be significantly lower then originally thought. This paper highlights how teachers define science instruction with the majority of respondents saying they integrate science content into language arts. Respondents also indicated they did not think science instruction in their schools was meeting the goals of the NGSS and that without systematic change time allocated to science instruction would continue to drop. When asked what they thought needed to occur in order for the goals of the NGSS to be met respondents overwhelmingly indicated that they needed more time, less pressure on other subjects and a change in the culture of education. Those who were hopeful they would see these changes take place cited the adoption of the NGSS as the catalyst for change.

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

Related Paper Set - Affordances and Constraints of Learning Progressions for Informing Teachers' Reasoning

2:30pm - 4:00pm, Grand Suite 5

Presider: Alicia C. Alonzo, Michigan State University

Discussant: Erin M. Furtak

ABSTRACT:
Contemporary views of teaching and learning call for "next generation" science teachers who are able to craft instruction that is both responsive to and builds on student ideas. Researchers have posited that learning progressions (LPs) can serve as a framework for organizing teachers' reasoning about students' ideas and, as such, may support teachers' instructional decision-making. In this related paper set, we explore the affordances and constraints of the LP construct for informing physics teachers' reasoning about their students' ideas and, thus, the potential of LPs to be used for instructional decision-making as envisioned by researchers. Taken together, the papers make an argument about the value of LPs at the classroom level. The general LP construct may help to focus teachers' attention on students' ideas and their development over time. Specific LPs may provide information about the nature of students' ideas for teachers without this prior knowledge. However, the premise commonly advanced by researchers that diagnosing students as being "at" a given level of the LP leads to actionable instructional decisions, should be reconsidered, particularly in the absence of agreement about the role of student ideas in instruction. We suggest implications for researchers, professional development providers, and teachers.

Using Learning Progressions to Support Pre-Service Physics Teachers' Noticing
Claudia von Aufschnaiter, Justus Liebig University Giessen
Alicia C. Alonzo, Michigan State University
Sophie Kirschner, Justus Liebig University Giessen

Physics Teachers' Use of LP-Based Assessment Information to Reason about Student Ideas and Instructional Responses
Alicia C. Alonzo, Michigan State University
Andrew Elby, University of Maryland

Using a Learning Progression as a Tool to Inform a Physics Teacher's Practice
Elizabeth X. de los Santos, Michigan State University
Deano Smith, Greenhills School

Using LP-Based Assessment Results in the Physics Classroom: A Teacher's Perspective
Alexander Robinson, Thornapple Kellogg High School

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Science Teachers' Knowledge and Beliefs
2:30pm - 4:00pm, Grand Suite 3
Presider: Patricia S. Dunac, Fayette County Schools

Influence of Physics Teachers' Professional Knowledge on Cognitive Activation in Classroom and on Students' Outcomes
Eva Cauet, University Dusiburg-Essen
Sven C. Liepertz, RWTH Aachen University
Andreas Borowski, University of Potsdam
Hans Ernst Fischer, University Duisburg-Essen

ABSTRACT:
One key to effective teaching is assumed to be teachers' professional knowledge. However, the connection of the three dimensions—content knowledge (CK), pedagogical content knowledge (PCK) and pedagogical

knowledge (PK)—to classroom or student variables has not been empirically elaborated in physics education research. This study investigated the relation between physics teachers' professional knowledge, students' cognitive activation in the same teacher's classroom and student achievement. Therefore, a sample of physics teachers (N=23) and their students (N=610) were tested and two consecutive physics lessons on mechanics were videotaped. Teachers' CK, PCK, and PK were measured by separate paper-and-pencil tests. Student achievement was measured by a multiple choice test in a pre-post design. Lessons were rated regarding the teacher actions supporting students' cognitive activation. The challenging results of this study are that whereas students' cognitive activation strongly correlates with student learning gains ($N=17$: $r=.6$, $p<.05$), we could not find any significant correlations to teachers' professional knowledge measures. Our findings question the validity of the PCK test, which is dealing with content accepted in the community, but normatively set. Moreover, the results emphasize the importance of connecting professional knowledge to classroom and student variables in order to prove that the measured knowledge matters.

Teachers' Professional Knowledge of Experiments and Models, Their Teaching, and Students' Learning Outcome

Martina Strübe, University of Duisburg-Essen Chemistry Education
Oliver Tepner, University of Regensburg, Germany
Elke Sumfleth, Universitaet Duisburg-Essen

ABSTRACT:
A central challenge for teachers is to support students in their development of subject matter knowledge. This challenge is influenced by various factors, such as students' prior knowledge, intelligence, or motivation. Also, it is influenced by the professional knowledge of the individual teacher, which usually is subdivided into the domain of content knowledge (CK), pedagogical content knowledge (PCK), and pedagogical knowledge (PK). Recently, particular interest has been directed toward CK and PCK, its components, its acquisition, and its influence on the learning progress of students. As the available studies mainly concentrate on mathematics education, the Related Paper Set addresses these issues in the field of science by assembling five studies, which pursue a variety of innovative methodological approaches. Four studies concern the nature of pre- and in-service science teachers' professional knowledge by particularly focusing on the components of CK and PCK as well as on the relationship between both domains of knowledge. Furthermore, one paper focuses on the development of the knowledge domains by investigating the relationship between CK, PCK, PK, and a set of learning opportunities. The last paper of the Related Paper Set relates biology teachers' content related knowledge to students' conceptual knowledge acquisition.

Can Teachers' Beliefs and Instructional Practices Effectively Predict Science Achievements of Middle School Students?

Ming-Chih Lan, University of Washington
Hongyan Newton, University of Washington
Min Li, University of Washington

ABSTRACT:
This study mainly examined the relationships among teachers' beliefs and instructional practices, and their student achievement in science. The researchers used the United States section of datasets from TIMSS 2011, both students and teachers, to explore these relationships with Hierarchical Linear Modeling (HLM) technique. The results indicated that, at the student level, six out of seven chosen variables were important explanatory variables accounting for variation in student performance as suggested in literature. At the class level, three out of five teacher variables were positively related to student learning. Student science achievements can be predicted by both teachers' beliefs and instructional practices. The findings implied that teachers' high expectation in student achievement and strong beliefs in students' desire to perform well in school play key roles to support student learning in science. The pedagogical methods and learning activities that the teachers

chose were also important to promote student learning. This study highlighted the combined ability of multiple teacher-related variables in predicting student achievement by both teachers' beliefs and instructional practices, and further suggested research in this area.

Teacher Knowledge and Student Attitudes in Context-Based Science Education
Erik Barendsen, Radboud University Nijmegen and Open University of the Neatherlands
Ineke Henze-Rietveld, University of Technology Delft
ABSTRACT:
Attitude development is an important aspect of modern science curricula. This study investigates the relation between teachers' knowledge and students' learning outcomes with respect to attitudes. We carried out an exploratory case study in The Netherlands using a context-based chemistry lesson module for Grade 9 students. In general, we observed that students' attitude outcomes show more variation in case the teacher's knowledge is more outspoken and coherent. In some cases, however, we found an incoherency in the teacher's knowledge and relatively rich learning outcomes. Our findings are consistent with results on studies concerning the role of reflection on practice in development of teacher's knowledge (Clarke & Hollingsworth, 2002; Wongsopawiro, 2012). The research method is interesting in itself. The applied approach, based on a model for teacher Pedagogical Content Knowledge and originally intended for teacher knowledge about cognitive, conceptual science content, turned out to be fruitful in analyzing teacher knowledge about attitudes. Moreover, the application of a 2-dimensional learner report format due to De Groot (1980) is promising for research on students' attitude outcomes.

Investigating the Alignment of Science Teaching Orientations to Instruction on Evolution among Secondary Teachers
Margaret M. Lucero, Santa Clara University
ABSTRACT:
This study introduced problem based cooperative learning (PBCL) to 1st year undergraduate physics labs and investigated the effect on students' understanding of the scientific method and on students' perception of their learning. The research incorporated one compulsory undergraduate physics lab for 200 students. 100 students took part in a traditional, manual-based lab to find the value of acceleration due to gravity and reported their findings following a conventional structure. The remaining students were assigned into small groups and were asked to find 'g' using any experimental approach they designed. These students presented their work within the lab for peer-review. At the end of term, each student completed an on-line survey, which incorporated student voice, following their participation in the lab and the generated qualitative data was analysed thematically. Students participating in PBCL reported more awareness of the scientific method, were engaged in their task, and their reflections highlighted the creative and collaborative nature of this active learning approach. Students following a traditional approach requested more exposition of content and assistance in compiling results, and reported far less engagement in the task. This initial study would suggest that participating in collaborative, cooperative, problem based learning is beneficial to undergraduate student learning.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Research Experiences - Mentoring
2:30pm - 4:00pm, Roosevelt
Presider: Stacey L. Carpenter, University of California - Santa Barbara

Mentoring Relationships Contribute to the Long-Term Academic and Career Outcomes of Undergraduate Researchers
Megan F. Campanile, Illinois Institute of Technology

Norman G. Lederman, Illinois Institute of Technology
Eric M. Brey, Illinois Institute of Technology

ABSTRACT:
More undergraduate students are participating in undergraduate research in the science and engineering disciplines at research universities. With the growth of undergraduate research, it has become impossible for faculty members to provide the one-on-one mentoring to all of the undergraduate researchers, therefore, the alternative has been to assign graduate students to mentor. It is established in the literature that undergraduate research influences the academic and career paths of the undergraduate students, however, the elements and processes of undergraduate research that contribute to these outcomes remain to be further examined. Thus, the purpose of this research is to examine how the experiences undergraduate students shared with faculty advisors and graduate student mentors in undergraduate research contribute to their long-term academic and career outcomes. This study targeted the 105 undergraduate students who participated in a Research Experience for Undergraduates (REUs) program between 2006-2013. Results indicate that the experiences they shared with faculty advisors have more influence than those with graduate student mentors on their academic and career paths. In conclusion, the findings provide evidence on how and to what extent the experiences students have with the faculty advisors and graduate student mentors contribute to their academic and career paths.

Dynamic Mentoring: Changing Mentoring Styles in a Summer Research Experience for Undergraduates

Gareth Wyatt, University of South Florida
Allan Feldman, University of South Florida

ABSTRACT:
Our study looked into the mentoring styles of graduate student mentors towards undergraduates during a Research Experience for Undergraduates program. Using the conceptual framework of research learning in the form of an apprenticeship (Lave and Wenger, 1991; Feldman et al., 2009; Sadler et al., 2010) we looked at how mentoring styles changed over the 10 weeks as mentees developed from novice researchers to proficient technicians. We found that mentors' styles varied along a continuum between "directive", where the mentor directed the mentee's learning, and "consultative", where the mentor acted as a consultant in the mentees' learning and development. We also found that mentoring styles cannot be adequately evaluated without considering mentees' own style preference, in a behavior we called dependence. Mentees' styles also existed along a continuum from being "dependent" on the mentors' direction, to being "independent" and directing their own learning. Using these two categorizations, we found that mentor and mentee styles could be plotted over time to show a progression of mentoring relationships. We believe that plotting such relationships could help visualize the learning progression in apprentice-like learning environments and help diagnose problems with mentor-mentee pairings.

Examining Mentoring of Undergraduate Science Researchers in Undergraduate-Postgraduate-Faculty Triads

Melissa L. Aikens, University of Texas at Austin
Erin L. Dolan, University of Texas at Austin

ABSTRACT:
Many undergraduate researchers are mentored by graduate student or postdoctoral researchers (postgraduates), who themselves are mentored by faculty, creating a mentoring "triad" configuration. Mentoring triads have not been the focus of empirical research, though faculty and postgraduate mentors likely provide unique contributions to undergraduate research outcomes. The goals of this study are to (1) empirically characterize the range of mentoring triad structures at research universities, (2) determine how different mentoring triad structures relate to outcomes experienced by undergraduate researchers, and (3) determine whether females or underrepresented students experience different mentoring configurations and outcomes. We surveyed undergraduate researchers and their postgraduate and faculty mentors about their interactions and the outcomes from the research experience. The triad with ties among all members was the most common mentoring

structure, and these triads resulted in greater outcomes than triads without an undergraduate-faculty tie. We also found differences between postgraduates and faculty in the function of their ties with undergraduates. Once data collection is complete, we will use moderated regression to examine how the strength of ties and function of ties relate to undergraduate outcomes. The results of this study will yield unprecedented insights into the latitude we have for designing undergraduate research experiences.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Research Experiences
2:30pm - 4:00pm, Columbus AB
Presider: Peter A. Okebukola, Lagos State University

Undergraduate Research Students' Knowledge of Scientific Methods: Overall Trend and Individual Differences
Omolola Adedokun, Purdue University
Loran Carleton Parker, Purdue University
Wilella Burgess, Purdue University
Dorothy Teegarden, Purdue University
ABSTRACT:
Undergraduate research experiences (UREs) are important learning experiences for students. While the benefits of UREs have been well documented, considerably less is known about the trajectories of student development during UREs and the differential effects of URE participation on students at various stages of their academic careers. This study employed multilevel modeling to examine the trajectories and patterns of change in knowledge of scientific methods among participants in a yearlong undergraduate research experience program. The study also explored academic standing and previous URE experience as potential predictors of individual variability in knowledge of scientific methods. Overall, the results suggest a curvilinear growth pattern where student knowledge of scientific methods increases over time, but with the rate of increase slowing down as time progresses. With regards to individual variations, the results showed that students do not develop equally in UREs. For example, although the initial levels were higher for senior than sophomore students, the rate of growth was slower for senior than sophomore students.

Development of a Performance-Based Measure to Assess the Scientific Thinking Skills of Undergraduate Researchers
Joseph A. Harsh, James Madison University
Adam V. Maltese, Indiana University
John Esteb, Butler University
Mikaela Schmitt-Harsh, Carleton College
ABSTRACT:
Undergraduate research experiences (UREs) are a vetted educational tool that is commonly perceived to prepare students for entering graduate school and careers in STEM fields. Despite the merit of prior literature in providing evidence to the effectiveness of UREs in augmenting participant skills, research to date has largely relied on self-report data, which may limit inferences about the causal effects of these experiences on student outcomes. To more objectively evaluate skill changes related to experimental problem solving and quantitative literacy, a performance instrument using open-response tasks situated in scientific problems and associated scoring criteria was designed, tested, and validated. In summer 2013, performance data were collected from chemistry participants (n=24) in summer UREs at seven institutions. Results of the study demonstrated the instrument to be a reliable assessment tool, and that participants made significant improvements in their problem solving and data analysis abilities over the course of their URE as well as identified potential gaps in ability. This exploratory work begins to fill a void in the literature by providing direct evidence to the effect of

UREs on student learning, which may be of particular interest to faculty and administrators for the refinement of UREs to improve student training.

Effects of Authentic Research on Undergraduate Biology Student Achievement
Brandon S. Diamond, University of Miami
ABSTRACT:
Universities throughout the world are working to improve science student achievement. An authentic research-based science curriculum was implemented at a major private university. Because most involved students were majoring in life sciences, cumulative GPA, biology GPA, and upper-level biology GPA were used as outcome measures of student achievement. College admissions test scores and high school GPA were used as covariates in the ANCOVA models. Authentic research was found to improve biology student achievement compared to a control group when introductory coursework was included in the GPA calculation. Test scores and high school GPA were found to be significant predictors of student achievement according to all three outcome measures.

Strand 6: Science Learning in Informal Contexts
Informal Science Experiences in an International Context
2:30pm - 4:00pm, Grand B
Presider: Che-Yu Kuo, National Taiwan Normal University

Comparing the Effect of Media on Measures of Scientific Literacy between Taiwanese and Chinese Students
Michael S. Tutwiler, Harvard
Pei-Ling Lin, University of Essex
Baojun Yao, Department of Life Sciences, Jiangxi Normal University
Chun-Yen Chang, National Taiwan Normal University
ABSTRACT:
In this exploratory study, we used a previously validated (Authors, 2011) novel instrument for assessing student scientific literacy to examine trends in Taiwanese and Chinese students across middle school, high school, and college cohorts. We found that student exposure to media, overall, was not related to their scientific literacy scores when controlling for student gender, interest in science, and grade level. We also found that high school students in both countries outscored their middle school and college aged peers, on average in the population and controlling for all other variables in the model. We found that males in both countries outscored females on average in the population, controlling for all other variables in the model. Finally, we noted that students were interested in science-based courses in Taiwan outscored their Taiwanese peers, controlling for all other variables in the model, but this was not the case for Chinese students. Further research is suggested.

Developing Scientific Literacy during International STEM Camp Programs
Judith S. Lederman, Illinois Institute of Technology
Stephen A. Bartos, Middle Tennessee State University
Allison Antink-Meyer, Illinois State University
ABSTRACT:
This study explored the influence of a summer science camp on students' conceptions of scientific inquiry (SI). Participants were a group of gifted Taiwanese students (n=19; grades 8 and 9) who were completing an 80-hour, summer science camp at a Midwestern university. In spite of evidence that these types of experiences can improve students' attitudes and interests related to science and science learning (e.g., Bhattacharyya, Mead, & Nathaniel, 2011; Fields, 2009; Gibson & Chase, 2002; Luehmann, 2009), gains related to science content for these short-term experiences are not well documented (Williams, Ma, Prejean, Ford, & Lai, 2007). The Views about Scientific Inquiry (VASI) questionnaire was used to capture students' views about SI before and after

camp participation, with modest gains evidenced for five of the eight aspects of scientific inquiry assessed. Implications for the design of these types of informal international science camp experiences as supporting the development of Scientific Literacy are discussed.

From Interest to Inquiry: Leveraging Student Interest to Teach Science Practices in Kenya
Anne E. Leak, University of California, Santa Barbara
Alexis Farag, University of California, Santa Barbara
Danielle B. Harlow, University of California, Santa Barbara
ABSTRACT:
In rural villages in Sub-Saharan Africa, there is often disparity between science curriculum taught in schools and the science that students experience in their everyday lives outside of school. When this disparity exists, students fail to be motivated by school science or perceive its purpose. In order to better connect science practices with students interests, we worked with teachers and students at an elementary school in Kenya to design an after-school health club. We found that students were strongly motivated by health issues in their community including AIDS, cholera, sports injuries, and malaria among others. Leveraging students' interests in these topics, we designed a curriculum that would teach students science practices related to chemistry, physics, environmental science, and engineering that would help address the health problems they had identified in their community. In this study, we use surveys, interviews, and ethnographic observations to explore what students in a Kenyan village were interested in learning and the ways in which these interests were leveraged for teaching science practices. Understanding how students express their interests in science, the underlying community context of these interests, and how to use these for curriculum planning has implications for fostering students' motivation to learn science.

Student Learning Experiences: Influences on High School Teachers' Science Pedagogy in Kenya
Samson Madera Nashon, University of British Columbia
David Anderson, University of British Columbia
Elizabeth Namazzi, University of British Columbia
ABSTRACT:
Our previous research has indicated that Kenyan teachers who often teach to the exam tend to resist reforming their pedagogy as they self-evaluate the success of their own practice directly as a function of student exam performance.. Hence, Kenyan teachers in most schools resist pedagogy reform because they see no need to reform what they consider to be working well and producing desirable outcomes. Furthermore, teacher performance and status is also largely connected to student performance on national exams. Using a teacher change framework that ascribes change agency to student learning experiences on science pedagogy, an interpretive case study involving in-depth interviews with selected teachers for analysis of transformations in their pedagogy after a contextualized curriculum experience demonstrated transformations in the way they organized learning experiences; redefined their locus of control; complemented individual with collaborative teaching of science subjects; and deconstructed their beliefs and attitudes about science subjects.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers' Subject Knowledge
2:30pm - 4:00pm, Columbus EF
Presider: Christopher A. Bogiages, Knowles Science Teaching Foundation

Content Knowledge for Teaching in NGSS Oriented Classrooms
Leonora Kaldaras, Michigan State University
Gail Richmond, Michigan State University

Joyce M. Parker, Michigan State University

ABSTRACT:
The Next Generation Science Standards call for a fundamentally different approach to learning science. They promote three-dimensional learning based on blending disciplinary core ideas, crosscutting concepts and scientific practices. In this study we examine content knowledge of secondary science teacher candidates (TCs) that is necessary for supporting teaching science in this three-dimensional way. Specifically, we focus on TC's ability to organize content into explanations. We are looking for TCs to give explanations of patterns in the data and to explicitly state underlying reasons for observed natural phenomena, as opposed to simply describing patterns or laws. In their methods courses, TCs were taught to organize their explanations into what/how/why framework, where what refers to what happens in specific cases, that is, data or observations, how refers to how things usually happen and is equivalent to patterns or laws, and why refers to causal explanations or models. We examined TCs' ability to do this spontaneously and in a resource-rich environment as first step in gauging their preparedness for teaching to the NGSS. We found that TCs give accurate accounts of patterns, but often fail to include causes or mechanisms. They also struggle to identify examples that clearly illustrate patterns.

Content Knowledge and Formative Assessment Integration in a Life Sciences Methods Course for Preservice Teachers

Jaime L. Sabel, University of Nebraska-Lincoln
Cory T. Forbes, University of Nebraska-Lincoln
Laura Zangori, University of Nebraska-Lincoln

ABSTRACT:
Preservice elementary teachers should learn essential science concepts, how to apply those concepts to practice in elementary science learning environments, and how to effectively connect students' ideas to appropriate instructional strategies. In order to effectively engage students in scientific practices and connect students' ideas about science to appropriate instructional strategies, teachers should learn to engage in high-leverage instructional practices, such as formative assessment. However, teachers may not understand formative assessment or possess enough science content knowledge to effectively engage in related instructional practices. To address these needs, we developed an innovative course for elementary preservice teachers built upon two pillars—life science disciplinary content and formative assessment. Students learned biological science content and how to connect disciplinary ideas to essential concepts in the K-12 science standards. The focus on formative assessment allowed preservice teachers to utilize content knowledge to identify and respond to students' ideas. Here, we present results of an embedded mixed methods study designed to evaluate the effect of this intervention on preservice teachers' content knowledge and ability to engage in formative assessment practices for science.

The Inner Structure of Prospective Physics Teachers' Pedagogical Content Knowledge

Yvonne Gramzow, University of Paderborn
Josef Riese, University of Paderborn
Peter Reinhold, University of Paderborn

ABSTRACT:
In research, pedagogical content knowledge (PCK) is considered as an important aspect of teachers' professional competence. However, there is no standardized definition concerning the internal structure of this concept, especially in science subjects such as physics. That directly leads to difficulties in comparing different empirical studies. Against this background, different conceptualizations and theoretical considerations of PCK have been consulted and compared. Based on these analyses, a comprehensive model of prospective physics teachers' PCK, including some typical German aspects, and a related test instrument (in the form of a pen-and-paper test) have been developed. Its purpose is to enlighten the correlations between certain aspects of PCK as well as between PCK and other areas of knowledge (e.g. content knowledge). Even if the instrument focusses

on the cognitive perspective of PCK, the relation to "PCK in action" is another relevant aspect to research. A think aloud study (N=15) as well as a pilot study (N=216) were implemented to research if the data fits to our theoretical structure of PCK. In this way, indications of the validity of the underlying model could be identified. Currently, the developing of the test instrument is complete and the end-product will be used for further analysis.

A Learning Progression for Preservice Elementary Teachers' Subject Matter Knowledge of Energy

Jingjing Ma, Texas Christian University
Channa N. Barrett, Texas Christian University

ABSTRACT:
Energy is a crosscutting concept in a framework for K-12 science education. There is extensive research about learning progressions depicting a derived pathway on how students understand this multi-disciplined concept. However, little to no research has been done for learning progressions of energy with preservice teachers. This study reports on our work of developing a learning progression of preservice elementary teachers' subject matter knowledge of energy. Thirty-four university students who enrolled in a science content course from a teacher preparation program participated in this study where they were given surveys of scenarios about energy; 15 of them were interviewed and asked for reasoning of their answers. We identified common misconceptions from teachers' statements from six specific scenarios. Two researchers independently and collaboratively coded both survey and interview data using four reiterative cycles. Our findings include descriptions of preservice elementary teachers' ideas about energy interpreted with five indicators and an evolutionary learning progression presented and illustrated with empirical examples from interviews. This study offers science education researchers and teacher educators an in depth examination of how preservice elementary teachers construct their ideas about energy, which can be used to improve teacher preparation programs or design teacher professional development.

Strand 8: In-service Science Teacher Education

Teachers' Readiness for NGSS

2:30pm - 4:00pm, Grand D North

Presider: Sherry A. Southerland, Florida State University

Negotiating Transition to the NGSS: Findings from a K-8 Professional Learning Project

Andy R. Cavagnetto, Washington State University
Chad Gotch, Washington State University
Olusola Adesope, Washington State University
Judy Morrison, Washington State University
Kathy Baldwin, Eastern Washington University
James Marr, Washington State University
Georgia Boatman, Educational Service District 123, Pasco WA

ABSTRACT:
This paper reports on findings from the first year of a professional learning project aimed at helping teachers immerse students in science practices to motivate learning of science concepts. An 80 hour summer institute and three academic year sessions emphasized the student learning, big ideas in science, and the integration of language practices into science pedagogy via the Science Writing Heuristic (SWH) approach. A quasi-experimental design is used to examine impact on student outcomes and influence of teacher implementation level on student outcomes. Variables of interest include critical thinking, academic motivation, and science knowledge measures of students as well as classroom instruction and teacher conceptualization of science instruction. The study provides additional insight into the influence of the SWH approach after a single year of

professional learning. It also informs the transition toward the Next Generation Science Standards with which many states are currently faced.

Teachers Grappling with NGSS and Common Core: Empirically Examining Lesson Study Teams
Christine Lee, California State University East Bay
Rich Hedman, California State University, Sacramento
Kathryn N. Hayes, California State University East Bay
Dawn O'Connor, Alameda County Office of Education
Jeffery Seitz, California State University East Bay
Rachelle DiStefano, California State University East Bay
ABSTRACT:
The Next Generation Science Standards (NGSS) puts forward a new vision to transform science teaching and learning by engaging students in authentic science practices towards deep understanding of content (NRC, 2012, 2013). Lesson study is a form of professional learning that occurs in the classroom, which may be especially productive in helping teachers shift their instruction towards the NGSS-aligned science education. However, a review of the literature indicates that there is a lack of available methodologies and tools to empirically examine the quality and merits of lesson study. To address this gap, set against the backdrop of current NGSS and Common Core reform, this study explores the following research question: How can the effectiveness of LS in supporting science teaching and learning be empirically assessed as teachers grapple with the instructional shifts required by new standards? Findings include a well-defined and theoretically grounded set of codes with related example evidence aimed to support efforts towards systematically assessing key constructs related to professional learning in science education research. The set of codes presented are timely given the present need to empirically assess and better understand the shifts towards NGSS-aligned practices.

Taking Steps towards the NGSS: Scientists and Science Educators Designing Standards-based Science Courses for Teachers
Jennifer Mesa, University of West Florida
Rose M. Pringle, University of Florida
Natalie King, University of Florida
ABSTRACT:
In this study, we investigated the question, "To what extent was middle school science teachers' science content knowledge impacted by formal science courses offered as a component of a larger professional development project?" Two cohorts of in-service middle school science teachers (N=35) completed a series of three specially-designed science courses (physics and chemistry, biological science, and earth and space sciences) as a part of the graduate degree program at a NSF-MSP-sponsored Teacher Institute for the 21st Century. In developing these courses, scientists and science educators collaborated to align the learning goals of each course with the content and practices of a next generation standards-based curriculum the teachers were required to teach. Teachers completed retrospective pre/post-course surveys for each course as well as a pre/post-course content assessment for the physical science course. Data analysis revealed that the teachers' content knowledge was positively impacted by their participation in the science courses, which suggests that they are now more prepared to implement the standards-based curriculum effectively. This research will be of interest to members of NARST who will be involved in designing the next generation of content-focused professional development and university science courses needed to prepare teachers to implement the NGSS.

Operationalizing Elementary Teachers' Understanding of and Readiness for Teaching within the Context of the Next Generation Science Standards
Gustave E. Nollmeyer, Eastern Washington University
Arthur Bangert, Montana State University

ABSTRACT:
This study was undertaken to identify and assess key constructs related to elementary teachers' understanding of the Next Generation Science Standards and readiness to teach science based on this new framework. As the community of science teachers strive to become Next Generation Science educators, the need for assessing prior knowledge to target areas of professional development will play a critical role. A survey instrument developed to measure teachers' understanding and readiness related to the NGSS framework resulted in the validation of two separate tools for assessing educators. The study also found that elementary teachers self-reported a "fair" understanding of Cross-Cutting Concepts and a "solid" understanding of Best Practices for Student Learning, Integration of the Three Dimensions, Science and Engineering Practices, and Teaching Disciplinary Core Ideas. Additionally, they rated their readiness to teach Cross-Cutting Concepts as "fair" and indicated "Solid" readiness for science instruction that addresses Students Learning as Scientists and Engineers, Integration of Real World Applications of Core Ideas, and Best Practices for Student Learning.

Designing for Culturally Responsive Next Generation Science Educators
Julie C. Brown, University Of Minnesota
Kent J. Crippen, University of Florida
ABSTRACT:
For individuals who are underrepresented in the STEM disciplines, success in science is increased when teachers integrate students’ cultural and linguistic backgrounds with challenging instruction. Embedded within the literature exploring such culturally responsive pedagogies in science education (CRP Science) is the professional development (PD) of CRP Science teachers who effectively educate underrepresented students. Although some scholars have begun to examine such programs, none have done so from a design-based perspective with the intent to produce usable knowledge about how to best construct these experiences. The purpose of this design study was to identify salient features of a job-embedded PD program supporting high school life science teachers’ professional growth. This qualitative investigation included the analyses of data from classroom observations, group interviews, and program artifacts. Analysis revealed that supportive program features included opportunities for teachers to: learn about their students’ lives in and out of school; develop critical perspectives on education; analyze lesson plans for the presence of reform-based, CRP Science instruction; and examine the impact of their practice on intended student outcomes and suggest appropriate instructional revisions. To generate usable knowledge about preparing CRP Science teachers through PD, we also present revised design principles.

Strand 9: Reflective Practice
Reflections on Students Conceptions, Reasoning and Understanting in Science
2:30pm - 4:00pm, Water Tower
Presider: Olufunmilayo I. Amosun, University of the the Western Cape

Investigating Secondary School and Junior College Students' Conceptual Explanations in Heat Transfer
Eugene Lim, National Institute of Education, NTU Singapore
Hye-Eun Chu, Nanyang Technological University
Daniel Kim Chwee Tan, National Institute of Education
ABSTRACT:
In the spiral curriculum, the thermal physics concepts were repeated from primary to upper secondary schools. However, there have been observations on inappropriate conceptual explanations in thermal physics across school years. It is mainly due to their difficulties in making connection between their experiences and teachers’ instructions. This study is to explore Year 8, 9 and 11 students’ conceptual progress through their conceptual explanations based on conceptual definition framework in heat transfer. Students taking physics subject in

school were given open-ended questions and thereafter interviewed after classroom instruction. Questions were based on common daily phenomena that probe students' understanding on heat transfer concept. It was found that the percentage of students who provided acceptable scientific explanation increases with school years. Year 8 and 11 students were consistent in their responses with the former providing inappropriate scientific explanations using descriptional definitions and the later providing acceptable scientific explanations using theoretical definitions. Also, the conceptual progress investigating consistency of students' conceptual explanation and definition were discussed. To help students understand the applicability of physics theory, teachers need to consider their prior understanding and provide more daily examples based on multimodal representations – hands-on experiment, demonstration, video and picture cards during classroom instruction.

Context and Constraints on Noticing in Classrooms of Early Career Science Teachers
Benjamin K. Campbell, University of Georgia
Ryan S. Nixon, University of Georgia
Julie A. Luft, University of Georgia
ABSTRACT:
Four early career science teachers were observed over the course of several classes, then interviewed immediately following each period of instruction. Instances of teacher noticing were identified and discussed during these semi-structured interviews. An instance of noticing is defined as an occasion in the classroom when a teacher notices and responds elaborately to a student's input. Each noticing event was isolated for analysis by means of a review of classroom observation notes and interview transcripts. Multiple passes through the notes and transcripts permitted the creation of one or more codes for each instance of noticing. Results provide detailed descriptions and themes about the context surrounding instances of noticing, as well as factors that influence teachers in their engagement in, and continuation with, responding elaborately to student thoughts and ideas in the classroom.

Using Next Generation Science Standards (NGSS): A Self-Study in Secondary Science, Engineering, and Mathematics Classes
Arthur F. Corvo, Teachers College - Columbia University
Felicia Moore Mensah, Teachers College, Columbia University
ABSTRACT:
The Next Generation Science Standards (NGSS), which are derived from the National Research Council's (NRC) Framework for K-12 Science Education, were published in April 2013 to aid science educators in preparing students for active and competitive participation in the 21st century. Teachers will need to adapt their practices to address these new standards. Given the NGSS's recent introduction, there is little research on how teachers can prepare for its implementation. To meet this research need, a constructivist sociocultural self-study aimed at examining preparation for the NGSS was conducted. The self-study used design-based, mixed, and multiple-case study methods to investigate an approach to learning, from design, enactment, and reflection on using NGSS-based units of study in secondary classes. Key data sources included designed unit plans, student surveys, and researcher reflections on classroom enactments. Quantitative data and qualitative data were integrated for analysis during the three phases of the study. Findings included improvements in unit design, assessment, discourse, and modeling. The findings have implications for in-service science teacher and pre-service teacher science education.

Pre-service Elementary Teachers' Attention and Pedagogical Reasoning through Video-based Reflection
Youngjin Song, University of Northern Colorado
Hye-Gyoung Yoon, Chuncheon National University of Education
ABSTRACT:

The purpose of this study is to explore pre-service elementary teachers' professional vision through video-based reflection on science teaching with foci of their attention and pedagogical reasoning about student learning. The primary data were collected from eight pre-service elementary teachers including their science lesson plans, videotaped lessons, video-reflection papers, and the transcripts from the interviews. Pre-service elementary teachers' attention was categorized in five aspects. The level of their pedagogical reasoning about student learning was determined with six levels based on three domains. The findings reveal that 1) pre-service elementary teachers paid more attention to the aspect of classroom management and climate without video-based reflection, 2) they noticed more about their own instruction after video-based reflection, and 3) there was no difference in their attention to the aspect of student learning through video-based reflection. The data also demonstrate that pre-service elementary teachers' pedagogical reasoning levels increased through video-based reflection in terms of 1) using more evidence to make assertions about student learning, 2) connecting student learning with other aspects of teaching, and 3) rationalizing student learning based on observation, their personal knowledge, and educational theory. The analytical framework and findings will provide implications for elementary science teacher educators.

Strand 10: Curriculum, Evaluation, and Assessment
Next Generation Science Standards (NGSS)
2:30pm - 4:00pm, Comiskey
Presider: Hendrik Haertig, IPN - Leibniz-Institut

Investigating Change in Classroom Instruction of Scientific Practices, Crosscutting Concepts, and Core Ideas
Rebecca L. Matz, Michigan State University
James T. Laverty, Michigan State University
Sarah E. Jardeleza, Michigan State University
Claire M. Morrison, Michigan State University
Zachary D. Nusbaum, Michigan State University
Sonny A. Ly, Michigan State University
Diane Ebert-May, Michigan State University
Joseph S. Krajcik, Michigan State University
Marcos D. Caballero, Michigan State University
Melanie M. Cooper, Michigan State University
ABSTRACT:
Our University is participating in a multiyear STEM education initiative designed to improve teaching and learning in introductory biology, chemistry, and physics courses. A major focus of the initiative is to engage disciplinary faculty in discussions about how we can incorporate scientific practices, crosscutting concepts, and core ideas (NRC 2012) into these classrooms. We call this construct three-dimensional learning and one of our goals is that the nature of classroom activities will change. We will measure this change over a three-year period with our newly developed Three-Dimensional Learning Observation Protocol (3D-LOP). The 3D-LOP characterizes both "what" students are taught and "how" they are taught. "What" students are taught refers to the content focus in the classroom, that is, scientific practices, crosscutting concepts, and core ideas of the discipline. "How" students are taught refers to the instructional strategies used by the instructor such as lecturing and clicker questions. Preliminary data are discussed that show high inter-rater reliability and strong content, construct, and face validity for the instrument. The 3D-LOP is the first observation protocol that assesses "what" is being taught in classrooms.

Supporting Next Generation Science Teaching and Learning with Curriculum Materials: Results from an Efficacy Study

Christopher J. Harris, SRI International
William R. Penuel, University of Colorado
Angela H. DeBarger, SRI International
Savitha Moorthy, SRI International
Cynthia M. D'Angelo, SRI International
Joseph S. Krajcik, Michigan State University

ABSTRACT:
The Framework for K-12 Science Education sets an ambitious vision for science learning by emphasizing that for students to achieve proficiency in science they will need to participate in the authentic practices of scientists. To realize this vision, all students will need opportunities to learn from high-quality curriculum materials where they engage in science practices. We report on our study of a middle school curriculum, Project-Based Inquiry Science, that has features aligned with the new directions in science education. To measure the impact of these materials, we conducted a randomized controlled trial in sixth grade science classrooms across 42 schools in an urban school district. We randomly assigned schools to either a treatment condition where teachers implemented the project-based science curriculum or a comparison condition where teachers implemented the district-adopted textbook. Teachers in both conditions received professional development on the Framework. Students who participated in the project-based science curriculum outperformed students in the comparison curriculum on outcome measures that were aligned to core science ideas and science practices in the Framework. Importantly, the results show that curriculum materials that incorporate science practices can impact the teaching practices of teachers who are striving to support next generation science learning.

A Curriculum Model for Integrating the Three NGSS Dimensions and Utilizing Published Biology Data

Nicola C. Barber, University of Utah
Martin M. Fernandez, American Association for the Advancement of Science
Jo Ellen Roseman, American Association for the Advancement of Science
Louisa A. Stark, University of Utah

ABSTRACT:
Realizing the vision for science education outlined in the Framework for K-12 Science Education and Next Generation Science Standards (NGSS) requires developing curricula that integrate disciplinary core ideas, science practices and crosscutting concepts. Attending to these three dimensions, we developed and tested high school biology lessons and closely-aligned assessment items on natural selection. The curriculum leverages the use of published scientific data to authentically integrate (a) the Life Science Disciplinary Core Ideas of Biological Evolution and concepts from Heredity needed to understand evolution, (b) the Science Practices of Analyzing and Interpreting Data, Using Mathematics and Computational Thinking, and Engaging in Argument from Evidence, and (c) the Crosscutting Concepts of Patterns, and Cause and Effect. Pilot testing the lessons via a treatment-only design revealed significant student learning gains from pre-test to post-test ($n=308$, $t=4.265$, $p<0.001$). Teachers reported on post-enactment surveys that the lessons differed greatly from how they typically taught natural selection but that they would continue to use the materials. Our work provides a model for curriculum development integrating the three dimensions of the NGSS with published scientific data and gives preliminary evidence of promise for this approach to increasing students' understanding of natural selection.

Comparative Analysis of Three Methods of Minimizing Bias Implications for NGSS Assessment Validity and Fairness

Christiana Nkechi Omoifo, University of Benin
Njideka D. Okomah, University of Benin/NABTEB

ABSTRACT:
The persistent concern about students' poor performance in science subjects has resulted in the development of science education reforms which are geared towards the development of tools for valid and fair assessment of

students. This study was an attempt to determine the validity of measures from chemistry test administered by an examination body after the implementation of a science education reform. Three methods, Transformed Item Difficulty, Mantel-Haenszel Chi-square and Empirical Item Characteristics Curve were used to identify biased items. Attempt was made to answer three research questions. The ex-post facto design was adopted. Multi-stage random sampling technique was used to sample scores of 1,172 candidates from six technical colleges. Factor analysis was employed to ensure uni-dimensionality of the test. Results show that 9, 35 and 36 items were identified as biased by TID, M-Hχ2 and EICC methods respectively. There is an agreement between the three methods in flagging six items as the most biased items in the measuring instrument. The biased items are of high cognitive domain. It is thus recommended that in developing and validating assessment tools for reforms such as the Next Generation Science Standards more than one method of identifying bias items should be employed.

Strand 11: Cultural, Social, and Gender Issues
Undergraduate STEM Success
2:30pm - 4:00pm, Columbus CD
Presider: Dorene R. Medlin, Albany State University

Motivation Factors Affecting Career Choice of Senior Women and Undergraduates in Information and Systems Engineering
Hagit Refaeli Mishkin, Technion, Israel Institute of Technology
Niva Wengrowicz, Technion
Dov Dori, Technion
Yehudit Judy Dori, Technion-Israel Institute of Technology
ABSTRACT:
Choosing science, technology, engineering, and mathematics (STEM) as a profession has been declining in general and among women in particular. According to the theory of planned behavior (TPB), choice is a result of a decision-making process, in which attitudes, subjective norms, and perceived behavioral control influence the intent and the behavior. Our goal is to identify reasons for the low rate of women choosing engineering careers. We examined the motivation TPB factors, as reflected by 12 women holding senior systems engineering positions and 330 undergraduate engineering students who took an information and systems engineering course. Both groups were asked what led them to choose STEM education and a future engineering career. Expanding on TPB, we developed and validated a motivation factor set that emerged from the senior women interviews. Analyzing the undergraduate students' responses based on this set of factors, we found that female undergraduate students used subjective norms as a choice factor more than males. Our study contributes to advancing the theory related to gender-dependent career choice by exploring gender-differentiating factors and sub-factors that expand on the theory of perceived behavior. The motivation factor set can serve researchers interested in encouraging women to choose and retain STEM careers.

Finding a Way to Belong: Negotiating Gender at University STEM Study Programmes
Lene Møller Madsen, University of Copenhagen
Henriette T. Holmegaard, Department of Science Education
Lars Ulriksen, University of Copenhagen, Department of Science Education, Denmark
ABSTRACT:
This paper presents a study exploring the issue of gender among first year students within different STEM higher education programmes. It is carried out in three study programmes that have a heavy imbalance in the distribution of student gender: computer science and physics & nanotechnology both educations with few female students and molecular biomedicine with few male students. The study explores how both female and

male students' perform their gender to attain recognition within their STEM study programme and how they negotiate their identities to gain a sense of belonging. Previous research has shown that the task of negotiating one's identity is a project for all students entering a higher education programme. The present analysis adds to this by showing how both minority female and minority male students additional need to engage in particular narrow gendered identity negotiation-processes to become socially and academically integrated into their study programme. To do this the students apply different gendered strategies related not only to their gender. Some strive to become like the majority by assimilation whereas some explicitly maintain their differences by segregation. It is argued that these differences are linked to the culture and perception of science knowledge within the study programme.

Ethnography of a College Physics Classroom: Identifying Gender Bias and Investigating Pedagogical Interventions

Diane C. Jammula, Columbia University

ABSTRACT:
This empirical study investigates gender bias in physics education through an ethnography of an introductory college physics classroom using the guided-inquiry curriculum Modeling Instruction. Physics is one of the least diverse sciences; only 21% of physics bachelors degrees are earned by women and 9% by racial and ethnic minorities (American Institute of Physics, 2010). Gender performance (Butler, 1999) is used to make sense of how students' gendered actions position them to be successful or unsuccessful in physics. The class was comprised of 23 students of diverse backgrounds and the researcher was the instructor. Data include fieldnotes and audio recordings of instructor and student interactions. Fieldnotes and transcripts were analyzed using open coding (Emerson, Fretz, & Shaw, 2011) and discourse analysis (Wood & Kroger, 2000) to answer three research questions: 1) How do students' performances of gender impact learning experiences? 2) What power/knowledge hierarchies exist in a physics classroom and how are students positioned in them? 3) How do pedagogical strategies work to reposition students to facilitate student learning? Findings discuss how gender performance impacts learning experiences and the efficacy of pedagogical interventions, with implications for research and teaching.

Strand 12: Educational Technology
Tools in Educational Technology
2:30pm - 4:00pm, Grand A
Presider: Robert H. Evans, University of Copenhagen

3D Printing Technology as an Educational Tool for Seventh Grade Students: Do Affordances Outweigh Constraints?

William J. McConnell, Old Dominion University
Daniel L. Dickerson, Old Dominion University
Petros Katsioloudis, Old Dominion University

ABSTRACT:
The Next Generation Science Standards, recently proposed as US national science standards, explicitly integrate engineering practices and/or content in all four components of their standards. In the recent past, both engineering education researchers and science education researchers have sought to find effective ways to integrate science and engineering. Few studies are available concerning middle school students and the use of computer assisted design software and 3D printing as tools for design-based science lessons. In this comparative case study, we collected various authentic student artifacts (notes, written explanations, computer designs, paper designs, exit ticket, videoed scientific discussion) from nine small groups of seventh grade students. We used

these sources to investigate the impacts of 3D printing technology on groups' design, expressed modeling, and scientific discussion. Findings include affordances and constraints to design and the design process as compared to paper drawings, groups' use of printed models to assist in oral discussion, feelings of ownership of models and individuals' desire to continue design modification. 3D printing technology, we contend, provided these groups learning opportunities not common in middle school science classes. Implications include the importance of scaffolding and the use of student discussion with 3D printing technologies.

A Self- Regulated Technology-enhanced Environment for Learning Skills in Science

Tali N. Shapiro, Weizmann Institute of Science
Bat Sheva Eylon, Weizmann Institute of Science
Zahava Scherz, Weizmann Institute of Science

ABSTRACT:
This paper proposes and describes a technology enhanced self-regulated learning and problem solving (TESR) environment designed to foster independent learning skills among students. Self-regulated learning subsumes key aspects of the learning process, such as cognitive strategies, metacognition and motivation, in one coherent construct. Central to this construct is the responsibility of students to take charge of their own learning. The object of the research described is to characterize the different self-regulating behaviours of students demonstrated while using the TESR environment in science class. An additional goal is to identify student help-seeking strategies and use of scaffolding embedded in the environment. Research was carried out during the 2014 school year in the context of 7th grade science curriculum that embedded the study of learning skills in science content. Data was collected from questionnaires, assessment tasks, think aloud protocols, and computerized tracing. Results indicate that scaffolding in the TESR environment facilitates student learning, and that reflection of the academic status of the student before working in the TESR environment has a positive effect on ability to select appropriate learning paths and seek help when needed.

Use of an Online Learning Environment to Enhance Experiences of Youth in Engineering Design Processes

Engin Karahan, University of Minnesota
Hui-Hui Wang, University of Minnesota

ABSTRACT:
In this study, we aimed at exploring the experiences of youth designing Rube Goldberg Machine. An online learning environment was designed based on adventure learning principles in order to promote the collaboration and interaction opportunities between peers and experts. A phenomenological study design was chosen in order to understand the essence of experiences about the phenomenon. The data was collected through the texts, images, and videos each design group posted on the online learning environment. Over 300 responses posted by 22 groups in two months were analyzed. The findings showed that the reflections of the design groups were mainly focused on engineering design process, conflict and group dynamics, and use of science content. In addition, the sub-themes emerged under engineering design process were gathering information, defining the problem, generating ideas, testing the design, and redesigning. The online learning environment helped design teams reflect their experiences and collaborate the peers and experts, which resulted with enhanced engineering design processes.

Using Wikis and Collaborative Learning for Science Teachers' Professional Development

Syh-Jong Jang, Chung-Yuan Christian University
Yang-Hsueh Chen, National University of Tainan

ABSTRACT:
Wiki bears great potential to transform learning and instruction by scaffolding personal and social constructivism. Past studies have shown that proper application of Wiki benefits both students and teachers; however, few studies have integrated Wiki and collaborative learning to examine the growth of science teachers'

Technological, Pedagogical, and Content Knowledge (TPACK). This study introduced a Wiki-based TPACK growth model and examined nine elementary and middle science teachers knowledge growth in a graduate-level course. Data sources included reflective journals, Wiki data, and interviews. Results showed that with Wiki, science teachers learned to design more interesting and lively science teaching content, and they collaboratively generated creative instructional strategies. Furthermore, Wiki and collaborative learning helped in-service teachers exchange and elaborate ideas related to the development of TPACK. Implications, suggestions and future research directions were put forward regarding Wiki, TPACK, and in-service teachers' professional development.

Concurrent Session #9
4:15pm – 5:45pm

Presidential Sponsored Session
Symposium - An Unconference on Engineering Education: Gearing Up for New Era of Global Science Education Reform
4:15pm - 5:45pm, Columbus KL
Presenters:
Valarie L. Akerson, Indiana University
Senay Purzer, Purdue University
Muhsin Menekse, University of Pittsburgh
Kristina Tank, Iowa State University
ABSTRACT:
This session will use an unconference format to promote dialogue on engineering education at the center of a new era of educational reforms that are emerging globally. Through small groups facilitated by science and engineering educators, the session will address both visionary questions that will guide future research as well as pragmatic questions on urgent issues that need to be addressed in near future. The visionary questions include: What have we learned from previous reform efforts in science education that can inform the successes of future reform efforts? What research questions should be answered in the next 5 years, 10 years and so on to inform effective teaching and learning globally? The session will address urgent and pragmatic issues by questions such as: How might we include engineering practices in undergraduate methods courses, science content courses and across all grade levels? How do we support science education faculty and graduate student professional development in engineering and engineering practices? How do we argue for the value of combining engineering and science practices in P-12 grades to various stakeholders such as parents? A white paper can be produced following this session.

Equity and Ethics Committee Sponsored Session
Symposium - Learning Science for Social Justice: Voices from the Field
4:15pm - 5:45pm, Wrigley
Presenters:
Daniel Morales-Doyle, University of Illinois at Chicago
David Segura, University of Illinois at Chicago
Esmeralda Villegas, DePaul University
ABSTRACT:
In this session, current students and alumni from Chicago's Greater Lawndale/Little Village High School for Social Justice reclaim the meaning of the term "social justice," and the name of their alma mater. The construct of "social justice" - its meaning, enactment, and implications - is undertheorized in the science education field.

Indeed, throughout educational research, the term "social justice" is often used without being adequately defined, which renders this term both meaningless and vulnerable to co-optation and commodification. The youth will share stories, class work, and projects that define, for them, what it means to "learn science for social justice." Panel members will discuss and reflect on the possibilities and challenges associated with engaging in this sort of science education in an era of high stakes and corporate reform in education. Multimodal artifacts, including audiovisual vignettes from the youths' science class, will support the presentation. The former and current science department chairs of the school will facilitate this interactive session which is intended to create dialogue between science education researchers and urban youth through a focus on the experiences, work, and ideas of high school students.

Administrative Sponsored Session
Symposium - Publishing Research for Practitioner Audiences: Tips and Strategies
4:15pm - 5:45pm, Water Tower
Presenters:
Deborah Hanuscin, University of Missouri
Julie Luft, University of Georgia
Victor Sampson, The University of Texas at Austin
Joanne K. Olson, Iowa State University
ABSTRACT:
Practitioner-focused journals, such as those sponsored by NARST's affiliate organization NSTA, can provide important venues for disseminating research and creating broader impacts. While organizations that publish journals for teachers, such as NSTA, emphasize research in their guidelines for authors, writing for a practitioner audience is much different from writing for a researcher audience. Teachers' need for knowledge arise from the immediate problems of practice they face, and are seeking practical implications of research to address those problems. In this session, facilitated by the NARST Liaison to NSTA, a panel of NARST members/researchers who have successfully published in NSTA's practitioner-focused journals will share their experiences and insights.

Strand 1: Science Learning, Understanding and Conceptual Change
Examples in Modeling Instruction
4:15pm - 5:45pm, Columbus GH
Presider: Cesar Delgado, University of Texas at Austin

Learning Inheritance through Modeling in Middle School Life Science Classes
Ronald W. Rinehart, Rutgers University
Moraima Castro-Faix, Rutgers University
Ravit Golan Duncan, Rutgers University
Clark A. Chinn, Rutgers University
ABSTRACT:
The development of explanatory models is a core scientific practice used by scientists to represent and make sense of the world (Giere, 2004; Godfrey-Smith, 2006). Modeling is recognized in the Next Generation Science Standards as an important practice for learning the practices and content of scientific domains. In this study 7th grade students engaged in the development of models of inheritance based on several sets of evidence. Some inheritance patterns represent phenomena that are counterintuitive for middle school students, so it was possible that students might not succeed in a guided-inquiry environment when they had very little prior instruction on this topic. Our research indicates that when students have the opportunity to construct and revise models, in

light of new evidence, they can spot gaps in their own knowledge and, by revising their models to account for these gaps, they develop a more causal and sophisticated account of inheritance. A guided-inquiry environment is beneficial for students to develop a grasp of the practice of modeling in addition to developing a better conceptual understanding of inheritance.

Studying the Impact of a Design Intervention on 3rd-Grade Students Model-Based Explanations for Water Systems

Cory T. Forbes, University of Nebraska-Lincoln
Laura Zangori, University of Nebraska-Lincoln
Christina V. Schwarz, Michigan State University
Tina Vo, University of Nebraska-Lincoln

ABSTRACT:
The Next Generation Science Standards emphasize that elementary students should engage in scientific modeling to begin developing robust conceptual understanding of hydrologic phenomena. However, scientific modeling remains underemphasized in elementary science learning environments and little past research has explored early learners' engagement in domain-specific modeling practices. For the past two years, we have worked with a small group of 3rd-grade teachers to explore strategies to more productively engage students in the use of models to learn about water systems. In this quasi-experimental, mixed-methods study, we present findings from a comparative investigation of 3rd-grade students' model-based explanations generated over the course of a standard and 'modeling-enhanced' version of a curricular unit on water. Findings from quantitative analysis of students' models suggest students experiencing the modeling-enhanced version of the water unit made significant gains in both conceptual understanding of the components of the water cycle and reasoning about water movement. Qualitative analysis of students' models and interviews further illustrate trends in students' model-based reasoning. Study findings contribute to research on scientific modeling in elementary classrooms and have important implications for teachers and curriculum developers.

Leveraging Mathematical Models in an Integrated Biology and Engineering Curriculum Enhances Student Learning

Anita Schuchardt, University of Pittsburgh
Christian D. Schunn, University of Pittsburgh

ABSTRACT:
To facilitate the adoption of the Next Generation Science Standards (NGSS), research is needed on effects of NGSS-aligned curriculum and practices on student learning. We have developed a 4-week NGSS-aligned curriculum unit on inheritance concepts that is centered on the practice of using mathematics in science and engineering. The mathematics is treated as a modeled process rather than just a calculated procedure. A pre- and post-test was administered to 1st year high school biology students implementing the revised (12 teachers) or traditional instruction (6 teachers), with students and teachers carefully matched on demographic features. ANCOVA and HLM analyses reveal that students taught with the NGSS curriculum showed greater pre-post gains compared to students taught the traditional curriculum in 1) their ability to solve typical inheritance prediction problems, and 2) qualitative understanding of biological processes. Further, mathematically modeled processes showed greater gains than nonmathematically modeled processes. This work provides an example of an effective NGSS-aligned curriculum that integrates biological science and engineering. It also shows that particular uses of mathematics that model entities and processes in the scientific phenomenon can enhance student learning of science.

Exploring 3rd-Grade Students' Model-Based Explanations about the Interactions between Plant Processes and the Hydrosphere

Laura Zangori, University of Nebraska-Lincoln

Cory T. Forbes, University of Nebraska-Lincoln
ABSTRACT:
Elementary students have a great deal of knowledge about the biosphere generally, and plant processes specifically, that they have developed through experience. However, the ways in which they conceptualize this system and if they consider interrelationships between the biosphere and other systems such as the hydrosphere is largely unexplored. We engaged 3rd-grade students in the practices of modeling (NRC, 2013) to explore their conceptions of and reasoning about plant processes and if they consider interrelationships with the hydrosphere. Our findings indicate that students engaged in elements of systems thinking through their sophisticated conceptions about plant processes that included hydrospheric relationships. Study findings contribute to research on scientific modeling and students' reasoning in the elementary grades and have important implications for both teachers and curriculum developers.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Learning and Discursive Practices
4:15pm – 5:45pm, Columbus CD
Presider: Shiyu Liu, Pennsylvania State University

Joint Engagements with Media that Supports Preschool Science Talk and Practices
Carlin Llorente, SRI International
Savitha Moorthy, SRI International
Ximena Dominguez, SRI International
Elizabeth Christiano, SRI International
Laura Pinkerton, SRI International
ABSTRACT:
Preschool science is an essential starting point to later science literacy and the possibility of selecting a STEM career and high quality early science learning experiences are especially important for children growing up in lower-income communities. This project complements recent research and development work by examining how a media-rich science curriculum supplement can support academically productive talk between teachers and preschoolers, and how this talk can serve as a robust foundation for a set of activities, including hands-on activities, that allow children to practice and refine authentic science practice skills while at the same time building new knowledge about their worlds. The curriculum supplement was implemented in one classroom over 8-weeks. Data collected for this study included 17 videotaped instructional days/ activities, distributed across all modules of the curriculum supplement. This paper focuses on the classroom talk observed during science learning experiences (both media-rich and hand-on activities), identifying and describing teacher-child interactions, and highlight the extent to which they supported children's participation in science talk and apprenticeship in science practices. Attention is paid to the use and response to closed and open ended teacher questioning, and how children's talk supported their burgeoning science practice skills.

Characterizing Shifts in Selena's Talk: A Study of Students' Discursive Participation in Afterschool Science Club
Minjung Ryu, Purdue University
Tiffanyrose Sikorski, George Washington University
ABSTRACT:
This case study documents and examines the stark shifts that one student, named Selena, made in her discursive participation during an afterschool science enrichment program called Science Club. Guided by responsive teaching practices (Hammer, Goldberg, & Fargason, 2012) and funds of knowledge (Moll, Amanti, Neff, & Gonzáles, 1992), the authors created Science Club in an effort to support students' participation in discursive

practices of science, and to demonstrate the flexibility and context-sensitivity of Asian students' stereotyped quietness in science class. The focal student, Selena, is an 8th grade, bilingual, Korean immigrant who attended all five weeks of Science Club. Through close analysis of video data collected during Science Club, we describe shifts in the frequency of Selena's utterances, the way she articulates her ideas, and her positionings in the club. Finally, we suggest implications for future research that seeks to support and analyze students' discursive participation in science.

Fostering the Emergence of More Equitable Teacher/ Student Dialogue Patterns During Science Inquiry
Carol A. Rees, Thompson Rivers University
Wolff-Michael Roth, University of Victoria
ABSTRACT:
Becoming next generation science educators requires a shift in teacher-student patterns of social interaction. Relying predominantly on the authoritative triadic dialogue pattern, the typical Initiation, Response, Evaluation sequence typical of teacher /student interactions in classrooms, has been identified as a barrier to science learning. Although triadic dialogue can have a positive function in students' learning to act in accord with accepted cultural practice, frequent opportunities for alternative more equitable dialogue patterns are required in classrooms. In this paper we argue, using examples from a grade 7/8 science inquiry classroom, that triadic dialogue, like other discourse patterns, emerges in precise association with the activities that are being enacted; regardless of the identity of the players who inhabit the roles in the turn-taking sequence. We further demonstrate that one way to support teachers and students shifting their patterns of interaction is to provide them with tools that foster the enactment of more equitable activities and the co-emergence of more equitable dialogue patterns during science inquiry.

Case Study of an Urban Elementary Teacher's Planning for Scientific Discourse
Elaine M. Silva Mangiante, Salve Regina University
ABSTRACT:
This case study examined decisions made by an elementary teacher, Ann, in a high-poverty urban district to foster a collaborative climate for scientific discourse. Since research indicates that student engagement in scientific discourse involves teachers' awareness of social norms and modes for student discourse with a focus on scientific meaning-making, the rationale for examining Ann's planning was to examine the decisions she made to enact these practices. Through interviews, document analyses, and observations during a science unit, the findings indicated she made a sequence of decisions that built students' capacity in discourse. First, she recognized the need to create a classroom climate whereby students felt safe to share their thinking. Next, Ann scaffolded students' acquisition of modes of discourse including using scientific language and voicing evidence-based claims as well as the social norm of listening to others. Finally, Ann planned for social norms and participation structures whereby students took responsibility for their active role to evaluate ideas, build on other's ideas, seek additional data, and consider alternative explanations. The results of this study take a step in describing the decisions of one urban teacher in planning for NGSS discourse practices of explanation construction, reasoning, and evaluation in her science classroom.

Strand 5: College Science Teaching and Learning (Grades 13-20)
The Power of Words in Science Learning
4:15pm - 5:45pm, Grand D North
Presider: Mark Urban-Lurain, Michigan State University

An Exploratory Study of How College Students Make Sense of Cancer in Writing-to-Learn Activities
Meena M. Balgopal, Colorado State University

Paul Laybourn, Colorado State University
Alison M. Wallace, Minnesota State University Moorhead
Ellen Brisch, Minnesota State University Moorhead

ABSTRACT:
Undergraduate biology students are under pressure to learn an overwhelming amount of content presented in foundational courses. We found in previous studies that writing-to-learn (WTL) tasks in small laboratory sections helped students improve quality of arguments and content knowledge. In this study we studied the transportability of WTL interventions to a large (n=80) cell biology course. Students participated in weekly WTL tasks for 15 weeks and generated three essays each. We conducted content and rhetorical analyses on a random selection of 10 students (30 essays) as we begin a systematic review of all student work. All ten students progressively included more cell biology content and more abstract concepts in their essays over the course. Students developed different lines of argumentation. Six students began their essays devoted to definition lines of rhetoric and then moved into proposal or evaluative arguments. Four students changed their claims within each iterative writing assignment, while six clarified and strengthened their claims over the writing assignments. All students drew on scientific evidence to support claims from journal readings, class lectures, and textbook in that order even though they were prompted to make personal connections. We conclude that WTL in college lecture course are valuable.

Computerized Lexical Analysis of Students' Written Responses for Diagnosing Conceptual Understanding of Energy

Mark Urban-Lurain, Michigan State University
Mihwa Park, Michigan State University
Kevin Haudek, Michigan State University

ABSTRACT:
While much research has been done about students' conceptual understanding of energy, the key ideas applied by students to answer energy concept questions have not been fully illuminated. This study explores the feasibility of using computerized lexical analysis for investigating conceptual understanding of energy. We used IBM SPSS Modeler to extract specific terms and categories from students' written responses to an energy question. We conducted a k-means cluster analysis to identify groups of similar responses. Using these methods, we identified key ideas used by students who answered both correctly and incorrectly. This technique effectively illuminated the existence of students' difficulties and alternative conceptions about this concept. The results showed that students who focused on surface-level information failed to answer the question correctly while students who used the underlying energy concepts along with information from the question were more likely to answer correctly. Our results support the use of computerized lexical analysis coupled with statistical analyses to gain insight into student understanding of energy concepts beyond what multiple choice questions can reveal.

Standardizing the Methodology of Textbook Content Analysis

Andrea M. K. Bierema, Michigan State University
Renee S. Schwartz, Georgia State University

ABSTRACT:
According to the National Research Council Committee (U.S.) on Undergraduate Biology Education to Prepare Research Scientists for the 21st Century (2003), biology curricula are not portraying current biological research frameworks, methods, and findings and instead are teaching students biology geared toward the past. However, there is little evidence in support of such teaching within the basis of curriculum, which is the textbook. In examining the few studies on college biology textbooks that do exist, no clear methodology has been established. Not only do studies rarely explain their method in detail, but they also rarely cite any other studies to justify their methods. Since we still know so little about the content covered in college biology textbooks and

because there is no clear methodology for analyzing textbook content, a methodology was developed. Methods from previous studies and described in qualitative research books covering content analysis were reviewed while establishing the methodology. This presentation will describe the developed methodology and provide a detailed account of how these methods were applied in identifying the conceptual frameworks of textbooks in a sub-discipline of biology: animal behaviour.

What Discursive Patterns Lead to a Highest Quality of Argumentation Mechanism In a Biochemistry classroom?

Annabel N. D'Souza, Graduate Center, CUNY
Wesley Pitts, Lehman College, CUNY

ABSTRACT:
Argumentation, which is the process of either supporting or refuting a conclusion using evidence and theory, has become increasingly important in science classrooms in K-16 institutions. It has been linked to increases in critical thinking and problem solving skills, and as a result, help prepare STEM majors for post-secondary education and beyond. This study seeks to explore 1) the discourse move sequences that exist in small group and whole class discussions in a chemistry inquiry-oriented activity on a mechanism in the TCA Cycle, 2) the discourse sequences that guide and facilitate argumentation, and 3) the discourse patterns that lead to the highest quality of argumentation (using Toulmin's Argumentation Pattern (TAP) framework). Data collection included video and audiotapes of weekly lessons for the duration of the course. To assess the quality of argumentation coding tools derived from studies on Inquiry Oriented Discursive Moves (IODM) and Toulmin's framework for argumentation were applied to event transcripts of group and whole class discussions. The results suggest that teachers and faculty members can support opportunities for argumentation by planning the activity and directing the discussion to include discursive moves that are prominent in the argumentation sequence thereby strengthening the process of argumentation.

Strand 6: Science Learning in Informal Contexts
Learning Processes in Informal Contexts
4:15pm - 5:45pm, Grand A
Presider: Benjamin L. Tupper, University of Michigan

Learning about Human Biological Systems with an Online, Casual Game

Katherine Gean, Museum of Science and Industry, Chicago
Aaron Price, Museum of Science and Industry, Chicago
Claire G Christensen, University of Illinois at Chicago
Bryn Pernot, Museum of Science and Industry, Chicago
Gloria A. Segovia, Museum of Science and Industry, Chicago
Patricia L. Ward, Museum of Science and Industry, Chicago
Steven Beasley, Museum of Science and Industry, Chicago

ABSTRACT:
Casual games are being used by science museums to engage guests in learning beyond the walls of the institution. Such casual games might not only increase museum learning opportunities, but may also be seen as supplemental learning tools in formal settings. However, there are very few experimental design research studies focusing on the learning outcomes casual games may provide. This study explored the effects playing an online, casual game has on awareness of human biological systems. As a part of an experimental design, 242 children were given pre- and post-tests which included playing either a treatment game or a similarly designed control game. The pre-test was given at a science museum and the post-test was taken at home. Forty-one children took part in an interview to further investigate the test results. No change was detected in attitudes of

children toward knowledge of their body. There was statistically significant positive change in their ability to describe how different bodily systems work together and their ability to identify the names of human biological systems. The results suggest that this is due to enhanced recall of prior knowledge and show a casual game's impact on awareness of relevant scientific concepts.

Visualizing the Tree of Life: Learning around an Interactive Visualization of Biological Data in Museums

Michael Horn, Northwestern University
Brenda Phillips, Boston University
E. Margaret Evans, University of Michigan
Florian Block, Harvard University
Judy Diamond, University of Nebraska--Lincoln
Chia Shen, Harvard University

ABSTRACT:
A goal of many science museums is to provide hands-on experiences in which visitors learn from exhibits and their interactions with other people. Advances in interactive computer displays coupled with new information visualization techniques have made it possible to offer experiences in which visitors "touch" and explore large scientific datasets. However, we know little about how such exhibits support learning. This study investigates visitor learning at an exhibit that visualizes a tree of life containing over 70,000 species. We recruited 248 youth at two natural history museums to participate in one of three conditions. In the first condition, the dyads interacted with our exhibit on a tabletop display. In the second condition, dyads watched a ten-minute video on the same topic. Individual responses on a 53-item post-interview were then compared to responses in a baseline condition. Participants in the tabletop condition exhibited substantially higher levels of social interaction than participants in the video condition. Further, compared to baseline participants, youth who interacted with the tabletop were also significantly more likely to reason correctly about evolutionary concepts including common descent, and shared traits. This could, in part, be due to the high levels of social interaction and self-directed engagement.

Mutual Processes of Learning during Family Visits to the Zoo

Chagit E. Tishler, Ben-Gurion University of the Negev
Orit Ben Zvi Assaraf, Ben-Gurion University of the Negev ISRAEL
Michael N Fried, Ben-Gurion University of the Negev ISRAEL

ABSTRACT:
Zoos are free-choice learning environments. Since zoos are visited largely by families Rogoff's 'guided participation' framework was particularly useful in describing and explaining the processes that were found in the present research during family visits to the zoo. This paper is part of a broader qualitative study that investigated learning processes in the zoo, how visitors use cultural tools and mediators that the zoo provides and the interactions among the visitors themselves. Our research question focused on what characterizes the interactions, processes and themes involved in learning during a family visit to a zoo. Our findings suggest that the processes of 'mutual bridging of meaning' and 'structuring of participation' constantly take place in the zoo. Parents and children use encounters with live animals to develop learning skills and transmit knowledge, they show agency in using these encounters for cognitive and affective development by using the cultural tools provided by the zoo. In addition parent responsiveness, was found to be important in enabling learning. Information from this study may be considered when designing mediation means in the zoo that assists parents in structuring learning of their children.

Reading Popular Science Texts and Textbooks: Evidence of a Performance Convergence Phenomenon

Rogerio G. Nigro, GEPEC

ABSTRACT:

This work is part of a set of data devoted to exploring several aspects related to the reading of science texts from the viewpoint of cognitive processes. Here we present knowledge associated with the reading of two genres commonly used in schools: textbooks and popular science texts. We found that 15-year-old students who read the popular science texts achieved higher scores in answer to an open-ended question aimed to verify the presence of ideas gleaned from the material they read. Despite the data that overall girls scored higher than boys; among the students who read the popular science text the performance of opposite gender students tended to converge. Among readers of the textbook excerpt however, performance convergence occurred among students with different levels of reading proficiency. The data obtained suggest that, in line with its genre, the expositive text structure can influence readers' manifestations of knowledge, even converging performance of boys and girls and of readers at different proficiency levels. This infers that comprehension based on reading is a complex phenomenon and informs science teachers of variables to be aware of in order to make judgments when choosing texts to be used in class.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers Developing Science Identities
4:15pm - 5:45pm, Columbus AB
Presider: David Stroupe, Michigan State University

Preservice elementary teachers should learn essential science concepts, how to apply those concepts to practice in elementary science learning environments, and how to effectively connect students' ideas to appropriate instructional strategies. In order to effectively engage students in scientific practices and connect students' ideas about science to appropriate instructional strategies, teachers should learn to engage in high-leverage instructional practices, such as formative assessment. However, teachers may not understand formative assessment or possess enough science content knowledge to effectively engage in related instructional practices. To address these needs, we developed an innovative course for elementary preservice teachers built upon two pillars—life science disciplinary content and formative assessment. Students learned biological science content and how to connect disciplinary ideas to essential concepts in the K-12 science standards. The focus on formative assessment allowed preservice teachers to utilize content knowledge to identify and respond to students' ideas. Here, we present results of an embedded mixed methods study designed to evaluate the effect of this intervention on preservice teachers' content knowledge and ability to engage in formative assessment practices for science.

Developing Science Identities: Exploring Influences in a Teacher Preparation Program
Daniel Birmingham, Loyola University Chicago
Lara Smetana, Loyola University Chicago
Elizabeth Coleman, University of North Carolina at Charlotte
ABSTRACT:
Despite recent reform movements and a renewed national dialog promoting the importance of science education, inequalities in opportunities to learn science in elementary school persist for students from underrepresented backgrounds as science continues to receive significantly less instructional time than math and literacy (Banilower et al., 2013; Judson, 2010) and the instruction that does occur tends to focus more on factual knowledge than deep understanding (Taylor, Jones, Broadwell, & Oppewal, 2008). While previous studies focus on lack of science content knowledge (Appleton, 2003) or the influence of standardized testing (Banilower et al., 2007) as mitigating factors for reduced time and quality of science instruction in elementary classrooms, our study provides insight into how teacher candidates' science identity, and their prior science learning experiences, influences the way they envision science instruction for their students. We argue that teacher candidates need opportunities to critically analyze their own science identities and how their previous experiences shape conceptions of who can do science and how it is relevant. Furthermore, we argue teacher

candidates need opportunities to experience leveraging hybrid practices when doing science in order to provide opportunities for all students, but especially students from underrepresented backgrounds, to build STEM identities

Is Agency Enough? When Pre-service Teacher Candidate's Designated Identity Overrides Teacher Preparation and Support

Angela D. Kolonich, Michigan State University
Gail Richmond, Michigan State University

ABSTRACT:
High-poverty schools struggle to attract and retain effective STEM teachers. One response to this problem has been the development of context-specific teacher preparation programs to help prepare STEM teachers specifically for high-needs schools. However, the successes and challenges faced by candidates in such contexts suggests that other factors also contribute to success and staying power. Our study follows two teacher candidates placed in the same urban school for their student teaching experience. Journal entries, classroom observations, candidate websites, and discussions with candidates were analyzed for evidence of teacher agency, values, and positioning over the course of the year. When values and designated identity aligned with the student teaching placement context, the experiences that the teacher candidate had reinforced their designated professional identity. When values and designated identity were in opposition to the placement context, our analysis suggests that a high level of contextual support and agency are not enough to alter designated identity. Analysis of the data suggest that placement context interacts in powerful ways with candidates' vision of themselves as professionals and thus placement is a critical factor in shaping aspirations as well as practices.

Navigating Emotions and Identity: Learning to Teach Science in a High Needs Setting

Karen Rose, Florida State University
Sherry A. Southerland, Florida State University

ABSTRACT:
As student populations in the United States become more diverse, teacher education programs are challenged to find effective ways to prepare teachers to be effective with these population. However, the goal of "science for all" continues to elude many students in urban and high needs settings where science achievement gaps persist, teacher turnover is high, and novice teachers are often hired to fill those vacancies. This set of three case studies explored the connections between preservice science teachers' emotions, identity and the implementation of student-centered science instruction during the participants' student teaching experience in high needs teaching contexts. Data included observations, interviews, an emotions dairy, and physical classroom artifacts. Multiple naturalistic observations were used to describe the interactions between the preservice teachers and the students during the implementation of student-centered lessons. Findings suggest that a merging of identity theory, control value theory, and situated learning is useful in explaining novice teachers' efforts to enact student-centered teaching practices during the student teaching experience in high needs settings. The insight provided by this research can inform the design of teacher preparation programs to allow them to more effectively prepare science teachers to be successful in high needs settings.

Strand 8: In-service Science Teacher Education

Effect of Professional Development Activities on Teachers' Knowledge and Practice

4:15pm - 5:45pm, Randolph

Presider: Marissa S. Rollnick, Wits University

Evidence of Teachers Enacting Science Practices in their Classrooms Following an Authentic Science Professional Development

Barbara A. Crawford, University of Georgia
Jaclyn Murray, University of Georgia
Alexandria Mazur, Michigan State University
Daniel K. Capps, University of Maine
Dongmei Zhang, University of Georgia
James Ammons, University of Georgia
Robert Idsardi, University of Georgia

ABSTRACT:
Teaching "science practices" aligns with earlier U.S. reform initiatives of teaching "science as inquiry". Teachers benefit from support to enact these kinds of sophisticated teaching practices through Professional Development (PD). In our PD we modeled the kinds of interactions between teacher and students that offer opportunity to investigate and grapple with data, develop/use models, analyze/interpret data, construct explanations, engage in argument from evidence, as well as communicate/defend explanations in an authentic setting. The purpose is to gather empirical evidence of how middle level teachers actually enact science practices in their classrooms, following an intense authentic science PD. The study is a follow-up to recently published one that determined overall positive, but varied changes in teachers' subject matter knowledge, views of inquiry/nature of science, and intentions to teach science as inquiry. In order to systematically analyze videotapes, we developed an observation matrix (Science Practices in the Classroom Matrix [SPCM]) that targeted NGSS eight science practices. We believe one of the strengths is the systematic analyses of what is actually happening in a classroom related to science practices. Findings could have important implications for designing PD and tracking the influence on knowledge, beliefs and practices, related to sophisticated ways of teaching science.

Science Teachers' Understandings of Science Practices: The Effect of an Environmental Engineering Research Experience

Dilek Ozalp, University of South Florida
Allan Feldman, University of South Florida

ABSTRACT:
The purpose of this study was to discover science teachers' understandings of science practices before and after they participated in an environmental engineering Research Experiences for Teachers (RET) program. Two research questions were addressed in this study: 1) What are the teachers' understandings of science practices before and after participating in the RET program? 2). How does science teachers' participation in an environmental engineering research experience affect their understandings of science practices? There were seven high school and three middle school inservice teachers and five preservice science teachers in the six-week program. The teachers were interviewed before and after the program by using a semi-structured protocol. The interview included 18 main questions. Four professors were asked the same questions about the science practices to get a sense of how experts understand them. Based on the codes and themes that were identified in the interview analysis a description is created for each science practice in each survey and they were compared. The findings indicated that the teachers had naive and incomplete understandings of science practices before they participate in an RET program. In addition, their understandings are still naïve and incomplete after they participated in an RET program.

Embedding Formative Assessment in Classroom Practice: Connections between Professional Development and High-School Chemistry Classrooms

Dante Cisterna, Pontifical Catholic University of Chile
Amelia Wenk Gotwals, Michigan State University

ABSTRACT:
In this case study we describe how two high-school chemistry teachers who teach in a similar context, differentially used what they learned about formative assessment in professional development (PD) as mediating tools to improve their classroom instruction. Drawing on cultural-historical activity theory (CHAT) and using evidence from PD meetings, teacher lessons, and teacher interviews; this study traces both teachers learning about and crafting a set of tools for formative assessment use in the PD and enacting these tools in the classroom. One teacher appropriated formative assessment as mediating tool to verify if the students were following her instruction and to check if the students were able to provide the correct response. The other teacher used formative assessment to promoting better understanding of students' ideas and her mindset shifted to place more value on the diversity of students' ideas. This study presents implications for PD models and formative-assessment research and practice. This study emphasizes the importance of promoting PD experiences that: (1) support teacher reflection about classroom practice in terms of activity systems, (2) use a research-based understanding of formative assessment, and (3) promote instances to teachers to craft, enact, and reflect on artifacts with formative-assessment purpose.

A Collaborative Approach to Delivering Science Teaching Methods Suitable for Addressing Diverse Large Classrooms

Rekha B. Koul, Curtin University of Technology
Vaille Dawson, University of Western Australia

ABSTRACT:
This paper reports the findings of NARST--LSEP funded project, where three day professional development workshop was conducted for Indian science teachers to enrich their teaching practices in diverse classrooms. Given the diverse socio-cultural nature of the student population of Indian classrooms it is imperative that science teachers be prepared to critically examine, reflect on and respond to practices for learners with diverse needs and from diverse backgrounds. Language development, students' contextual understanding, world-views, quantitative and visual spatial reasoning skills and social skills, all contribute to preparing students to become productive scientists. While these aspects are found in varying degrees across students in classrooms in any part of the world, addressing them poses a challenge in the face of greater socio-cultural diversity, e.g. diversity in ethnicity, religion, region, habitat, language, and gender. Indian science teachers were introduced to and then engaged in inquiry based teaching methods based on the Australian Academy of Science, 'Science by Doing' materials. The professional development workshop provided opportunities for teachers to ask questions and work collaboratively with their peers to generate novel solutions using their science content knowledge. Most teachers enjoyed the workshop and found the content useful.

Making Science Authentic, Local, and Relevant: Evaluation of CityEco Teacher Professional Development Design and Impact

Sheron Mark, Loyola Marymount University

ABSTRACT:
Science rooted in everyday, recognizable cultural experiences of students can be a powerful pedagogical approach in increasing the representation of low-income, racial/ethnic minority students who excel in science. Furthermore, as students' science interest begins to wane as early as middle school, immersing students in authentic scientific cultural practices, e.g. scientific inquiry and problem-solving (engineering), as opposed to abstract, text-based instruction and memorization of facts, earlier may circumvent loss of student interest and decline in student academic performance. This research study reports on the evaluation of the CityEco (a pseudonym) teacher professional development designed to train teachers to support students in technology-rich, culturally-relevant, authentic STEM practices. This approach to teacher PD critiques traditional models of science education, which assumes that all students will understand and/or value science presented as abstract facts and unbiased knowledge. CityEco promotes science as being everywhere, as interdisciplinary, and as the

domain of all students and community members. Teacher PD as opposed to only student intervention has the potential to impact students sustainably and at a large scale extending far beyond any university-K12 partnership or infusion of funds.

Strand 8: In-service Science Teacher Education
Examining Science Teacher Leadership
4:15pm - 5:45pm, Comiskey
Presider: Julie C. Brown, University Of Minnesota

Tracking Emergence and Development of Entrepreneurial Teacher Leaders in Science Teaching and Learning Networks
Matthew M. Schroyer, University of Illinois
Fouad Abd-El-Khalick, University of Illinois
Anita M. Martin, University Of Illinois
Caroline Haythornthwaite, University of British Columbia
ABSTRACT:
Outside the context of schools, social networks are acknowledged to be important for learning, yet social network analysis has only been used recently in education research. A multi-year, large-scale Math Science Partnership (MSP) aimed to nurture entrepreneurial teacher leaders who could expand their district's teaching and learning networks, in order to seize opportunities to innovate in their classrooms, disseminate innovations in their school buildings and districts, and work toward reform-oriented science teaching modalities. This study builds on previous work done by the project that documented changes in a rural school district's teaching and learning networks over time, and also tracks the emergence and development of entrepreneurial teacher leaders. The district faced internal challenges over this period with regard to turnover, but as teachers engaged in innovative curriculum reform and professional development, science teaching and learning networks strengthened in several important indicators. Key to these science teaching and learning networks were teachers who participated in the project's entrepreneurial leadership training. These entrepreneurial teacher leaders developed additional ties, disseminated innovations to their colleagues, bridged gaps in the networks, and forged ties to important actors. Similar methods could empower other programs with knowledge of how their PD initiatives impacted teaching and learning networks.

From New Teacher to Peer Leader: Exploring Teacher Practice in an Online Induction Program
Joshua A. Ellis, University of Minnesota
Samuel J. Polizzi, Kennesaw State University
Gillian H. Roehrig, University of Minnesota
Gregory T. Rushton, Kennesaw State University
ABSTRACT:
This presentation outlines a comparison study that investigates the impact of Teachers as Leaders roles on interactions within an Exploration of Practice activity in an online induction program for new STEM teachers. This program has been continually developed through design-based research strategies, the purpose of which is to improve the ways in which teachers interact in an online induction environment. This study explores data from the 2012-2013 and 2013-2014 academic years in order to answer the question: What is the impact of Teachers as Leaders roles on the frequency of teacher interactions, group cohesion, and depth of reflection in the Exploration of Practice activity? The study includes quantitative, visual, and qualitative analysis, rendered through a sequential multi-phase approach. Phase I identified no statistically significant effect of Teachers as Leaders roles on the frequency of group interactions. Phase II revealed higher incidences of non-presenter-centric network patterns and group cohesion resulting from Teachers as Leaders roles. Phase III indicated an

increase in higher-level depth of commentary following the introduction of Teachers as Leaders roles. These findings are of particular relevance to STEM instructors of online or hybrid courses who wish to promote critical thinking, reflective commentary, and community-oriented practice among their participants.

High School Science Teachers' Enactment of Instructional Leadership for School Improvement

Stacy A. Wenzel, Loyola University Chicago
Megan E. Deiger, Loyola University Chicago
Jonya A. Leverett, Loyola University Chicago

ABSTRACT:
Teacher leadership has emerged as a crucial lever for schools aiming to implement instructional changes such as those necessitated by the Next Generation Science Standards. The current paper aims to contribute to an area that researchers have argued is in great need of exploration: that of a more comprehensive understanding of instructional leadership. This poster describes findings from an exploratory study of a sample of high school science teachers who recently finished participating in a five-year professional development project aimed at offering them a chance to increase their knowledge and skills around subject matter, pedagogy, and teacher leadership. We analyze a set of qualitative survey, interview, and observation data from eleven high school science teachers by means of grounded theory analysis methods and through the lens of an original framework for investigating how teacher leadership impacts instructional quality. Our findings suggest that teachers who (1) had high levels of program participation, (2) reported having learned new leadership skills, (3) held formal leadership positions, and (4) reported meaningfully collaborating with peers also reported better school gains in the form of new and improved science courses, improved instruction, and integration of math and science across the curriculum.

Teacher Leadership Identity Development Process: A Multiple Case Study

Somnath Sinha, University of Missouri-Columbia
Deborah L. Hanuscin, University of Missouri-Columbia

ABSTRACT:
Teacher leadership has been recognized time and again as a crucial ingredient for improvement of school education.Current studies have investigated attitudes of teacher leadership, different forms of leadership, factors affecting leadership, applicability of leadership development models, and role of principals. However there has been no study so far exclusively focusing on 'how' teachers develop as teacher leaders. Within that backdrop, this study investigated the process of teacher leadership development of three high school science teachers in a multiple case study approach. The results indicated both similarities and differences. The overall leadership development process was similar across all the participants and it involved a synergy among their leadership views, practices and identity. However, the particular pathway of leadership development was unique for each teacher.

Supporting Science Teachers in Seeing Themselves and the System from a Leadership Perspective

Brett Criswell, University of Kentucky
Greg Rushton, Kennesaw State University

ABSTRACT:
An NSF-funded Noyce Track II project on which the authors are PI and Co-PI has operated for three years. One of its overarching goals is to support a group of 16 chemistry and physics teachers (Master Teaching Fellows, MTFs) on a trajectory towards teacher leadership. Previously, the authors (Author 1 & Author 2, 2013) have described a model that has been used by the project team to structure the professional development experiences of the MTFs. In this paper, we describe the outcome of our analysis of data intended to determine the extent to which the MTFs have internalized key constructs within that model, and thus used those constructs to guide their discourse and actions related to being a teacher leader. That data includes transcripts of professional

development sessions, email exchanges, blog posts, focus group discussions, and individual interviews. The analysis indicated that the MTFs have imputed significant meaning to these constructs and have come to see them as guiding principles for directing their leadership efforts. By showing the correlations between the MTFs adoption of these constructs and their understanding of functioning as a teacher leader, we provide recommendations for designing professional development for science teacher leaders.

Strand 10: Curriculum, Evaluation, and Assessment
Symposium - Building an Integrated Understanding of Energy through K-12 Teaching
4:15pm - 5:45pm, Gold Coast
Presider: Joseph S. Krajcik, Michigan State University
Discussant: David Fortus, Weizmann
Presenters:
Knut Neumann, Leibniz Institute (IPN)
Sascha Bernholt, Leibniz Institute (IPN)
David L. Fortus, Weizmann Institute of Science
Ute Harms, Leibniz Institute (IPN)
Joseph S. Krajcik, Michigan State University
Yaron Lehavi, The Hebrew University of Jerusalem
Jeffrey Nordine, San Antonio Children's Museum
Sebastian T. Opitz, Leibniz Institute (IPN)
Ilka Parchmann, Leibniz Institute (IPN)
Ulrike Wernecke, Leibniz Institute (IPN)
ABSTRACT:
Energy is not only a core idea in every science discipline, but also a concept cutting across (and beyond) the science disciplines. Past research has focused on identifying 1) the key ideas about energy students need to understand in order to develop a deep understanding of the construct and 2) how students progress in their understanding of these ideas. However, while there is a broad research base suggesting that students develop a deep understanding by developing an increasing number of connections between these key ideas, there is little research on how this kind of understanding can be built through teaching. Based on a summary of research on students’ understanding of energy, we will, in a series of presentations, discuss recent findings on students' learning about energy, students’ learning about energy as a cross-cutting concept, the importance of students' understanding for future learning about energy, the representation of energy in curriculum materials, and one of the most prominent approaches to teaching energy. Finally, we will present three potential approaches to teaching energy discussed in the literature. We aim to discuss these approaches with respect to students learning about energy.

Strand 11: Cultural, Social, and Gender Issues
Race, Language, and Science Practices
4:15pm - 5:45pm, Roosevelt
Presider: Malcolm B. Butler, University of Central Florida

Using Research-Practice Partnerships to Support Equity-focused Implementation of NGSS In and Out of School
Philip L. Bell, University of Washington
Megan Bang, University of Washington
Angela Calabrese-Barton, Michigan State University
William R. Penuel, University of Colorado

Erin M. Furtak, University of Colorado
Felicia Moore Mensah, Teachers College, Columbia University
Shirin Vossoughi, Northwestern University
Carol D Lee, Northwestern University

ABSTRACT:
For better and for worse, the implementation of national-level education standards is currently unfolding across a vast number of states, districts and schools—with many informal educational institutions also supporting these efforts. This panel discussion will explore the strategies, challenges, and promising directions associated with supporting implementation of the Next Generation Science Standards (NGSS) from an equity and social justice perspective. The efforts that will be shared and discussed during this session are R&D projects conducted through collaborative partnerships of researchers and practitioners. Some projects engage in implementation research at relatively large scale (e.g., across one or more school districts); others are design research efforts exploring new possibilities for learning within specific settings. Some of the efforts happen within the context of formal schooling; others occur within cultivated learning environments out-of-school. The panelists will discuss the equity-focused strategies being employed in these efforts, the problems of educational practice being encountered, the contributions being made to research and practice, and promising directions and priorities for the projects and for the broader science education field. The session attempts to highlight productive models that support hope and possibility in the context of largely under-resourced and complex attempts to engage in systems-level educational improvement.

Confronting Barriers to Inclusivity: Planning and Implementing an Accessible Geoscience Field Course for Students with Disabilities

Christopher Atchison, University of Cincinnati
Anthony Feig, Central Michigan University
Brett Gilley, University of British Columbia
Alison Stokes, University of Plymouth
Julie Hendricks, University of Cincinnati

ABSTRACT:
Students with disabilities are commonly marginalized from full participation in science courses, encountering significant barriers to access and inclusion in learning experiences that take place outside of the classroom, in the natural environment. In order to increase talent and diversity in the geoscience workforce, more inclusive learning opportunities must be developed that will enable all students to complete the requirements of undergraduate degree programs, including fieldwork. An international team of geoscience education researchers collaborated in the design and delivery of a fully-accessible field course recently conducted in Vancouver, BC. Of the 30 participants, 18 had a sensory, physical or cognitive disability. This unique field course brought together current geoscience instructors as well as undergraduate and graduate students with disabilities to share perspectives on commonly-encountered barriers to learning in the field and explore methods and techniques for overcoming them. The outcomes of this project provide more than just a single geoscience learning experience; they have the potential to significantly change the way in which current field-based science programs are promoted and offered. Project outcomes will be discussed, including the development of accessibility guidelines for inclusive instructional practices in field-based experiences through the perspectives of both students and faculty.

Supporting Students in High School Science Classrooms for Students with Sensory and Orthopedic Disabilities

Dale R. Baker, Arizona State University
Lisa Lacy, Arizona State University
Cean Colcord, Arizona State University
Heather Pacheco-Guffrey, Bridgewater State University

ABSTRACT:
Data from interviews of high school science and special education department heads schools found that they had not received specific instruction in undergraduate or graduate training to address the needs of students with orthopedic or sensory disabilities in science classes. Nor, did professional development provided by districts address the needs of students with disabilities to support learning science. Most respondents spoke of learning on the job and from one another. Most schools had limited assistive technologies specifically for learning science. Schools lacked funds and infrastructure to provide the assistive technologies that could help students and most teachers were unaware of the free technologies available to them through the state and university supported program. Either because of lack of knowledge about available technologies or lack of training, teachers were more interested in ways to modify lessons and curricula than employing technologies, in their teaching. Although teachers were concerned about the welfare and success of their students with disabilities, they felt that disabilities placed limitations on students concerning the rigor of the curriculum. Everyone reported that students with sensory and orthopedic disabilities were most often placed in regular science classrooms. However, no students were placed in honors or advanced placement science classes.

Critical Race Theory Critique of Next Generation of Science Standards
Eileen R. Carlton Parsons, University of North Carolina at Chapel Hill
Dana Thompson Dorsey, University of North Carolina at Chapel Hill
ABSTRACT:
Critical race theory (CRT) was employed in a critique of the Next Generation of Science Standards (NGSS). Critical discourse analysis and deductive coding indicated that interest convergence, counter storytelling, and racism as ordinary, three CRT themes, were present in the NGSS treatment of race. Interest convergence was evident in framing the justifications for NGSS. Counter storytelling was implicated by the absence of perspectives in the information provided to contextualize disciplinary content. Racism as ordinary was indicated in the positioning of diversity within the NGSS text, citing of demographics, and the discussion of resource allocations. In the absence of specific guidance, NGSS rely heavily on educators in their implementation to address race-related issues. Guidelines for professional development are offered.

Peer Support and the African American Scientist: Using Critical Race Theory to Explore Science Success
Shari Watkins, University of Delaware
ABSTRACT:
Using CRT as the framework in this study, I employ counter-story to analyze the science success of one African American woman scientist, Dr. Jenkins (a pseudonym) as she recounts her undergraduate, masters, and doctoral science experiences at three institutions of higher education. Interview was used as the primary data source to capture her first hand perspective (voice). Two counter-stories are presented: Peer support as a Positive Experience and Lack of Peer Network as a Painful Experience. These narratives emphasize how race impacts networks of peer support and has implications for how higher education institutions can provide structures where supportive peer networks can emerge.

Strand 11: Cultural, Social, and Gender Issues
Teacher Practices
4:15pm - 5:45pm, Columbus IJ
Presider: Emily Dawson, University College London

Comparison of Pedagogical Content Knowledge between US and Korean Science Teachers
Soonhye Park, University of Iowa
Kyungwoon Seo, University of Iowa

Jee Kyung Suh, University of Iowa
Aeran Choi, Ewha Womans University

ABSTRACT:
National reports calling for the reform of Science, Technology, Engineering, and Mathematics (STEM) education stress the importance of high quality teachers to improve the quality of student learning in STEM fields. Along with the empirical research that supports the close relationship between teacher quality and student success in learning, Pedagogical Content Knowledge (PCK) has been identified as a critical contributing factor to student learning of a subject by research and educational reform documents. While the results from the Trends in International Mathematics and Science Study (TIMSS) reported a significant difference in students' achievement in science between the US and Korea, this study is aimed to examine the linkage of students' progress with teachers' level of PCK by comparing US science teachers' scores on a PCK measure with Korean teachers' scores. From the analysis of 85 US and 81 Korea surveys, Korean science teachers showed higher levels of PCK than their counterparts in US. Moreover, teaching subject and teaching certification areas appeared to be closely related to PCK scores for US teachers, which was not very evident for Korean teachers. PCK score comparisons with other relevant factors, and the implications of the findings are discussed.

Science in an Indigenous School: Insight into Teacher Beliefs about Science Inquiry

Azra Moeed, Victoria University of Wellington, New Zealand
Craig RofeVictoria University of Wellington, New Zealand
Dayle Anderson, Victoria University of Wellington, New Zealand
Rex Bartholomew, Victoria University of Wellington, New Zealand

ABSTRACT:
Internationally, students' non-engagement in science is an issue. In New Zealand, the number of Māori/indigenous students in senior sciences is particularly low. Māori medium schools (wharekura) seek to provide rich learning experiences in Te Reo Māori (Māori language) and students develop their cultural identities in a supportive environment. Little is known about their science learning. This paper reports beliefs of two wharekura teachers about science teaching and learning. Data were collected through in depth interviews that were audio-recorded and analysed. The study highlights mutual trust, willingness to learn, and respect for each other's worldviews a necessary element for this collaboration between researchers and teachers. Findings suggest that even though the teachers doubt their subject matter knowledge, but one of them has deep understanding of the nature of science inquiry and once modelled, translated it into practice. The second teacher brings a wealth of pedagogical knowledge, knowledge of her students, and the philosophical understandings of the wharekura context. Beliefs about how students should learn include fruitful possibilities for learning through science inquiry in wharekura. Research reported here is part of a larger project that focuses on science learning through doing science inquiry in elementary, high school and wharekura in New Zealand.

Multicultural Elements in a Science Teacher Education Program: The Viewpoints from its Graduates

Muhammad Abd Hadi Bunyamin, University of Minnesota
Bhaskar Upadhyay, Uniersity of Minnesota

ABSTRACT:
A science teacher education program (TEP) plays the central role to produce quality science teachers with the ability to teach considering the educational diversity. This study aims to illuminate the voice of three graduates of a physics TEP in Malaysia with regards to the multicultural education. I utilized the interview method to collect the data on the viewpoints of the graduates with respects to the curriculum of the TEP and its internship program. The main finding indicates that the TEP put little effort to expose its preservice teachers with the diversity and equity issues in the physics education. Several steps should intentionally be taken in order to strengthen the future physics teachers with the dimension of cultural diversity in the education.

Increasing Levels of Achievement for Black Science Students: Learning from the Experiences of Effective Teachers

Tonjua B. Freeman, University of Central Florida
Mary M. Atwater, University of Georgia

ABSTRACT:
The achievement of Black students in the United States continues to fall below the achievement of their White classmates. The purpose of this multiple case study was to seek science teachers' pedagogical philosophies related to increasing levels of achievement for Black students in science. Critical race theory was used as the theoretical framework. Four high school biology teachers (one Black male, one White male, and two White females) from two rural, public schools in the Southeastern region of the United States shared their philosophies about helping Black students to attain high levels of achievement in science. Data were collected through interviews, classroom observations, demographic questionnaires, and lesson artifacts. While there were multiple findings, the findings can be broken down into four categories: (a) teacher characteristics, (b) student characteristics, (c) classroom environment, and (d) instruction, curriculum, and assessment characteristics. The participants suggested such things as integrating students' lives into lessons, creating comfortable classroom environments, using varied instructional strategies and assessments, and developing positive relationships with students and parents. The findings have implications for further research, particularly with regards to the importance of parental involvement and support.

Doing Better: A Cross-Case Analysis towards a Framework for Equitable Science Pedagogy

Manali J. Sheth, Iowa State University

ABSTRACT:
Our current system of science education is inequitable for students of color living and learning in urban areas. Students of color regularly experience less rich and self-affirming science learning opportunities than their peers from dominant groups even when sitting in the same classroom. Although concern for more equitable science education has been growing in policy documents such as Science for All Americans and the Next Generation Science Standards, a great deal of work remains to be done to support the science education community in articulating and realizing what equitable science education could be for students of color and how science teachers can be supported in developing equitable science teaching practices. Towards answering these questions, I engaged a multiple case-study analysis of three teachers committed to student science learning and academic success to explore their efforts and struggles towards equitable science pedagogy. Cross-case analysis supported a refined framework for equitable science pedagogy in which: 1) Seeing race and culture and sharing responsibility for learning form the ESP foundation. 2) Ideas from these dimensions are filtered through teachers' stances on science. 3) Teachers' practices towards critiquing structural inequities, nurturing student science identities, and re-centering student epistemologies reflect both domain-general and -specific components.

Strand 12: Educational Technology
Using Technology to Capture Student Learning
4:15pm - 5:45pm, Columbus EF
Presider: Georgia Hodges, University of Georgia

Leveraging Technology to Measure Student Learning during Inquiry Based Virtual Case Studies in Introductory Biology

Georgia Hodges, University of Georgia
J. Oliver, University of Georgia
Sophia Jeong, University of Georgia

Allan Cohen, University of Georgia
Yoonsung Jang, University of Georgia
Tom Robertson, University of Georgia
David Ducrest, Interactive Science in 3D

ABSTRACT:
Researchers will discuss findings from a large-scale longitudinal study that examined student learning of fundamental biological concepts before, during, and after the deployment of Skills and Assessment Based Learning Environment (SABLE) modules. Researchers and teachers (n=6) partnered to implement a quasi-experimental design to measure learning outcomes associated with the use SABLE modules. During the first year of data collection, students (n=423) were assessed using a validated pre- test before partner teachers (n=6) began a two-week instructional unit on cellular structure and function, then utilized a validated post-test measure upon completion of the unit. During the treatment year, teachers utilized the same pre- and post-test measures while deploying the new SABLE modules with students (n=453). Repeated measures ANOVA revealed two latent classes of students whose learning outcomes varied significantly during the treatment year. Specifically, 66% of students initially identified as low achieving students and 84% of initially identified as high achieving students were classified as high achievers during the treatment year. Conversely, zero students changed groups during the non-treatment year. Researchers then analyzed embedded data from the SABLE modules to explain the growth in student knowledge and understanding of problem-solving skills captured by the validated assessment during the treatment year.

IVE-based Science Assessment: Multiple-Choice versus Free Response Student Performance in Diverse School Environments

Kelly M. Mills, University of Maryland
Ashley N. Coon, University of Maryland
Uma Natarajan, University of Massachusetts, Boston
Diane Jass Ketelhut, University of Maryland
Xiaoyang G. Gong, University of Maryland
Brian C. Nelson, Arizona State University

ABSTRACT:
School socioeconomic status (SES) is strongly associated with student achievement, with low school SES correlating to low achievement. SAVE Science is an NSF-funded project designed to assess middle school science content and inquiry by contextualizing assessments within immersive virtual environments (IVE). In this study, we investigate how students at two schools with different average SES levels compare in terms of IVE-based assessment performance, as measured by multiple-choice questions compared to free response questions. While students from the high SES school perform significantly higher on the multiple-choice questions (Coon et al., 2015), students from low SES school perform significantly higher on the free-response questions. This study suggests that eliciting student understanding in multiple ways may be a strategy to change the relationship between school SES and academic achievement.

Capturing Changes in Children's Computer Programming Ability While Playing Scratch

Taylor Martin, Utah State University, Active Learning Lab
Phil Janisiewicz, Angile Dynamics
Kevin Close, Utah State University, Active Learning Lab

ABSTRACT:
Computational thinking has been considered as one of the most critical skills for everyone in this growing technological society. This leads to the importance of computer science in K-12 education and the increasing interest of learning computer programming for K-12 students. There is also a need to integrate early programming alternative opportunities into core instruction, such as Science instruction, so that students have

more opportunities to engage in developing their programming skills over time through core content applications. The Next Generation Science Standards includes applications of computers for modeling and simulations. While there is growing knowledge of ways to engage students in computer programming at a young age, little is known about how assess students' individual progress while learning programming. Scratch, which is a visual, media-based programming platform, can be an effective tool to introduce computational thinking to students and examine how the students construct their knowledge about computer programming concepts while working with Scratch. In this study, we developed an analysis tool to efficiently capture whether there were significant changes in fifth-grade students' ability to program while developing their Scratch projects.

The Redundancy Principle of Multimedia Learning in a Next Generation Science Classroom: Measuring Learning Outcomes
Robert C. Wallon, University of Illinois at Urbana-Champaign
ABSTRACT:
The objective of this study was to investigate if the redundancy principle, an established principle in cognitive psychology, could account for potential differences in learning outcomes from a video used within the context of a problem based science unit. A quasi-experimental design was used to compare learning outcomes between redundant (N = 30) and nonredundant (N = 20) conditions in a high school biology class. Findings indicate that the redundancy principle could account for some, but not all, differences in learning outcomes. Implications for teacher use and development of multimedia as well as implications for researchers measuring learning outcomes in classrooms are discussed.

Strand 13: History, Philosophy, and Sociology of Science
Pre-Service Education
4:15pm - 5:45pm, Grand Suite 5
Presider: Allison Antink-Meyer, Illinois State University

Investigation of Pre-service biology teachers' Conceptions about Theories, Laws, and Models
Bianca Reinisch, Freie Universität Berlin
Dirk Krüger, Freie Universität Berlin
ABSTRACT:
Researchers demand an extension of currently studied nature of science (NOS) aspects. Following this, the project includes not only research about theories and laws, but also about models as another important product of scientific activities. The underlying methodological framework - the model of educational reconstruction - demands among others the recursive clarification of science subject matter and investigation of learners' conceptions. Thus, pre-service biology teachers' (N = 5) concepts about theories, laws, and models in biology, their tentative nature, and their relationships to each other were assessed in interviews, analyzed by means of the qualitative content analysis, and compared to philosophical stances. The results show that the interviewees primarily have in mind educational functions of models, e.g. to illustrate a theory, and barely mention epistemological aspects of theories and models. There is an ongoing debate about the existence of laws in biology by philosophers. Analogously interviewees hardly could name any law in biology. Finally, it is suggested for future NOS research especially in biology to focus more on theories, models, and regularities as a form of empirical generalizations than on laws.

Relationship between Pre-Service Teachers' Views of Nature of Science and Study Subjects
Suat Celik, Ataturk University
Faik O. Karatas, Karadeniz Technical University

ABSTRACT:
The aim of this study was to investigate pre-service science and mathematics teachers' views of the nature of science and to find out any relationships between their views and their study subjects. For this aim the Views on the Nature of Science (VNOS) questionnaire was administered to 220 pre-service science and mathematics teachers from departments of chemistry, physics, biology and mathematics in both Faculty of Education and Faculty of Science. The participants' responses to VNOS questionnaire were analyzed by employing a coding theme based on seven aspects of the nature of science. Chi-Square test was implemented to analyze data to check the relationship between the pre-service teachers' views of NOS and their study subjects. It was found that less than 50% of the participants' views of certain aspects of NOS are considered as "informed," except subjectivity nature of scientific knowledge and role of creativity and imagination in science. A relationship was found between the participants' views of NOS and their study subjects for five out of seven aspects of NOS. Implications for science teacher education and for future studies are discussed.

How do Pre-Service Biology Teachers Explain the Origin of Biological Traits? : A Philosophical Analysis
Kostas Kampourakis, University of Geneva
ABSTRACT:
In this paper, the explanations that preservice biology teachers provided for the origin of biological traits are analysed, using a framework that draws on philosophy of science. The results indicate: a) that teachers' explanations depended on the context of the task given each time, b) that they had specific difficulties in distinguishing between explanations to "Why?" and "How?" questions and c) that they mostly provided genetic determinist rather than developmental explanations for the origins of traits. Teaching future teachers some philosophy of science and relating it to specific content knowledge and pedagogical content knowledge might contribute to addressing these problems and enhance teachers' competence.

Strand 14: Environmental Education
Conceptual Models in Environmental Education
4:15pm - 5:45pm, Grand Suite 3
Presider: Patricia Patrick, Texas Tech University

Exploring Preservice Teacher's Mental Models of the Environment and the Influence of EE-centered Methods Courses
Amy Trauth-Nare, University of Delaware
Michelle Nappi, Towson University
ABSTRACT:
In this study, we explored the nature of preservice elementary teachers' mental models of the environment and the influence of EE-centered methods and practicum courses on their mental models. Data were collected from preservice teachers' written course documents, which included written reports, course reading responses, reflective writing prompts and curriculum projects. Data were subjected to analytic induction to develop themes related to the research questions. Findings indicated the majority of PSTs held mental models of the environment tightly tied to the local ecosystem. In particular, many PSTs mentioned the regional watershed as a place for observing nature, interacting with organisms and engaging in independent exploration and leisure activity. PSTs perceived field-based inquiry activities, reading and reflecting on EE-related literature and the tight connection in content and pedagogy between the methods and practicum courses were most influential in shaping their ideas about the environment. This study adds to the existing research on how to best prepare PSTs to teach environmental and sustainability topics in K-12 classrooms and reinforces the pressing need to more comprehensively integrate EE into preservice teacher education.

Modeling the Relationships among Pre Service Science Teachers' Cultural Environmental Bias, Nature Relatedness and Energy Related Behaviors

Birgul Cakir, Middle East Technical University
Ozgul Yilmaz-Tuzun, Middle East Technical University

ABSTRACT:
In this study, a hypothesized model investigating the relationships among cultural environmental bias (CEB, nature relatedness (NR) and energy related behaviors were suggested for this study. In addition to this, although the relation among NR sub dimensions has not been reported based on a data, this relation is also investigated in the hypothesized model. There were 320 pre service science teachers participating in the study. The path analysis with AMOS revealed that all paths proposed in model were not significant. After the deletions of insignificant paths, the fit indices appeared to represent a theoretically sound model. The proposed model suggested a direct influence of CEB to energy related behaviors, the direct paths between CEB sub dimensions and energy related behaviors were found to be insignificant. The path analysis and zero order correlation results together showed that the relation between CEB and energy behaviors is mediated by NR. In terms of the relationship among NR sub dimensions, NR-perspective influence both NR-self and individuals' intention to have an experience with nature. NR-self also has an influence on individuals' desire on nature related experience. This relationship among NR sub dimensions is important since only NR-self directly has an influence on energy behaviors.

Comparing Students' Mental Models Before and After a PowerPoint or Field Work Experience (Experiential Learning)

Patricia Patrick, Texas Tech Unviersity
Sara Jose, Texas Tech University

ABSTRACT:
The mental models students have of the environment are a helpful tool for evaluation, because mental models represent their prior knowledge of the topic and are an insight into how they view the natural world. This mixed methods study combined place-based education and experiential learning theory to determine secondary students (ages 15-18) mental models of a local delta environment and how the mental models changed after an in class presentation or after a field trip (field work experience)? Participants included 90 students, who watched a PowerPoint presentation, and 192 students, who visited a local delta and completed field work experiences, were asked to complete drawings and write descriptions of their drawings. Ten students from each group were interviewed about their drawings. The findings show that both groups of students had an increase in knowledge of the local delta, but students who completed the field work experiences had the largest increase in knowledge. Overall, this study shows that place-based, environmental education that includes field work experiences increases students' knowledge of their local environment. Environmental education that takes place in the field and includes hands-on field activities enables students to better understand local general science concepts, such as the local delta.

Strand 15: Policy

Symposium - Connections in Two Directions: Building Relationships Between PCK Research and Science Education Policy Initiatives

4:15pm - 5:45pm, Grand B

Presider: Jan H. Van Driel, Leiden University

Presenters:

Amanda K. Berry, Leiden University
Janet Carlson, Stanford University

Patricia J. Friedrichsen, University of Missouri-Columbia
Vanessa Kind, Durham University
Pernilla Nilsson, Halmstad University
Jan H. Van Driel, Leiden University

ABSTRACT:
The purpose of this interactive symposium is to explore connections between PCK research and policy areas related to science teacher development. Our aim is to explore connections in two directions, that is, we will discuss possible implications of recent PCK research for policy initiatives in science teacher education, professional development and curriculum reform and, vice versa, given some of these initiatives, what do we know from research on PCK and what research would be needed in the future? The symposium will include four contributions. In the first one, international science education policy documents, among others on teachers' standards, will be interrogated to resolve how current PCK research fits, and to identify points of dissonance. The second contribution aims to demonstrate that strong PCK improves students' science experience in the classroom, implying the important role of PCK in making science more attractive. The third contribution focuses on reform of science curricula, in particular, on the role of educative curricular materials to develop teachers' PCK, thus enhancing the chance of successful innovation. Finally, in the fourth paper, teachers' PCK development is framed in terms of learning progressions. From a policy perspective, this has potential advantages, but also presents important challenges.

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

International Committee Sponsored Session
Current Directions of Research in Science Education from Australia and New Zealand
8:30am - 10:00am, Grand D North
Discussant: David F. Treagust, Curtin University
ABSTRACT:
This contribution, on behalf of the Australasian Science Education Research Association (ASERA) draws on examples of contemporary research from Australia and New Zealand to consider future directions for science education and science education research. During the symposium comprising 5 papers, arguments will be made for the following: Real science is multidisciplinary, value-laden, and messy and is often learned outside the classroom (Rennie). Student engagement has emotional, behavioural and cognitive components, and teaching needs to be cognisant of this (Corrigan, Panizzon & Lancaster). Futures thinking is one component of developing skills relevant and required in a changing world that can engage students in science learning, but requires shifts in teachers' content knowledge and PCK (Buntting & Jones). Shifts in science education practice require different types of assessments (Cowie, Moreland & Glynn). Re-examining pedagogical reasoning as outlined by Shulman can be used to articulate the expertise of science teachers (Keast, Mitchell, Panizzon&Loughran). If science education and science learning are to become a lifelong endeavour for our students, whether as professionals or citizens, these papers present significant implications for science as part of compulsory education.

Science Beyond the Classroom: Real, Messy and Value-laden
Léonie J Rennie, Curtin University

Pursuing Different Forms of Learning Science through Innovative Curriculum Implementation
Deborah Corrigan, Monash University
Debra Panizzon, Monash University
Greg Lancaster, Monash University

Developing Students' Futures Thinking through Science
Cathy Buntting, University of Waikato
Alister Jones, University of Waikato

Culminating Exhibitions and Performancs as Compelling Opportunities for Science Learning and Assessment
Bronwen Cowie, University of Waikato
Judy Moreland, University of Waikato
Edward Glynn, University of Waikato

Re-examining Peadgogical Reasoning as Means of Identifying Science Teacher Expertise
Stephen Keast, Monash University
Debra Panizzon, Monash University
John Loughran, Monash University
Ian Mitchell, Monash University

Strand 1: Science Learning, Understanding and Conceptual Change
Motivation, Interest, Attitudes, and Self-Efficacy
8:30am - 10:00am, Grand B
Presider: Steven Mcgee, Northwestern University

Disguising Physics: The Effects of Contextual Features on Students' Motivation and Performance
Marcela Pozas, University of Koblenz-Landau
Patrick Löffler, Graduate School Teaching & Learning Processes
Wolfgang Schnotz, University of Koblenz-Landau
Alexander Kauertz, University of Koblenz-Landau
ABSTRACT:
The use of context-based problems in science education has shown to influence students' attitudes towards science (Bennett, Lubben, & Hogarth, 2006). Despite extensive research on the topic, it is still unclear it is still unclear how the design of these task characteristics can influence students' motivational variables such as interest, anxiety and probability of success in a physics problem-solving task. The aim of the current study was to examine how the task characteristics of context-based physics problems influence students' motivational and affective states, their self-efficacy and to what extent this influence is moderated by students' prior knowledge and cognitive abilities. Eight versions of a thermodynamics task were presented to 207 students of grade 10th in a physics class. Tasks were designed with the factors contextualization (low/high) and transparency (low/high). Before and after the task was solved, students were tested for their situational interest, anxiety, and their own probability of success. Results suggest that context-based problems in physics learning can contribute to students' situational interest and reduce their anxiety. This is due to the fact that task characteristics disguise the abstract nature of the underlying conceptual structure.

The Impact of Text Genre on Science Learning in an Authentic Science Learning Environment
Steven Mcgee, Northwestern University
Amanda M Durik, Northern Illinois University
Jess K. Zimmerman, University of Puerto Rico
ABSTRACT:
A gap exists between research on learning and research on interest. Cognitive researchers rarely consider motivational processes, and interest researchers rarely consider cognitive process. However, it is essential to consider both since achievement and interest are in fact intertwined. In this paper we (1) discuss a theoretical model that intertwines cognitive and interest development, (2) describe how that model informed the development of educational materials, and (3) report on the results of the cognitive components of a randomized research study examining the impact of text genre on learning and interest. In our prior analyses, we examined the effects of text characteristics (i.e., narrative or expository genre) on situational interest. We found that students with higher levels of prior individual interest preferred the narrative versions of text whereas students with lower levels of prior individual interest preferred the expository versions of text. In this paper, we examine the impact of text characteristics on student learning. The results of this research showed that contrary to prior research, there was no significant difference in comprehension based on text characteristics. These results provide evidence that is possible to differentiate instruction based students' prior interest without sacrificing learning outcomes.

Longitudinal Changes in Students' Attitudes towards Natural Sciences during Transition to Secondary School
Alexandra Moormann, Humboldt-Universität zu Berlin
Annette Upmeier Zu Belzen, Humboldt-Universität Zu Berlin
ABSTRACT:

The global intent of science education is the individual development of students and the development of competencies, knowledge, skills, and attitudes. Many researchers pointed out that students' attitudes towards natural sciences decline over the school years. Among them, some studies suggest that the transition to secondary school impacts learning and hence indirectly impacts attitudes as part of competences. To understand this "swing away from science", the aim of this longitudinal study is to investigate the development of students' attitudes towards natural sciences, especially around the sensitive transition phase between primary and secondary school. The research is based on the attitude expressions scale (Christen, 2004) that allows measurement of four students attitudes: enjoyment of learning, aim- and achievement orientation, boredom, and frustration. The attitudes of 728 students (age 5 to 13) were characterized by questionnaires. In line with other studies, our results show a decrease in the number of students who enjoy learning, and an increase in the number of bored students over the school years. However, our results also indicate that the transition to secondary school have a positive effect on the attitudes towards natural sciences, by triggering the aim- and achievement orientation and declining the number of bored students.

Explaining Students' Choices of Post-Compulsory Chemistry

Maik Walpuski, University of Duisburg-Essen
Carolin Huelsmann, University of Duisburg-Essen

ABSTRACT:
In several countries chemistry is one of the disciplines with physics and maths which suffers most from the high dropout rates in upper secondary school and tertiary education (OECD, 2008). Due to insufficient participation in chemistry, this study uses questionnaire data from German chemistry students in upper secondary school to identify predictors of course choice and students' success in chemistry at secondary level. Deriving from factors influencing course choice which are discussed in literature, students' interest, subject-specific knowledge, grades and their ability self-concept as well as their career aspirations and the perceived relevance of the subject will be surveyed in a quasi-longitudinal study with two points of measurement spanning one academic year involving 9-12 students. The findings indicate that students' interest, ability self-concept and career aspirations play a significant role as predictor of chemistry choice while chemistry grades seem to be less important.

Effects of Key Facets of Motivation and Self-Regulation on Students' Conceptual Understandings on Electric Current

Hüseyin Inaltun, Gazi University
Salih Ates, Gazi University

ABSTRACT:
The purpose of this study was to confirm a hypothesized model to explain how key facets of motivational beliefs and self-regulation related to students' conceptual knowledge on electric current. The research sample consists of 127 students (girl=107, boy=20) who enrolled in science education program of a public university in the Ankara, Turkey. The Turkish version of students' adaptive learning engagement in science questionnaire was used to measure students' beliefs on key facets of motivation (learning goal orientation, task value, self-efficacy) and on self-regulation (effort regulation). Concept map technique was used to measure students' conceptual knowledge level of electric current. The hypothesized model were tested with Maximum Likelihood estimation. The results of the path analysis showed that all motivational beliefs learning goal orientation, task value and self-efficacy explained 35% of the variance in self-regulation. Furthermore, both self-regulation and self-efficacy explained 14% of the variance in the students' conceptual knowledge. These findings show that educators should take into consideration students' motivational beliefs and self-regulation to increase students' conceptual knowledge.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Chemistry Education in Context
8:30am - 10:00am, Columbus CD
Presider: Wondimu Ahmed, The University of Akron

Group Interactions Contributing to Differential Opportunities for Learning in a General Chemistry Studio Learning Environment
Melinda Z. Kalainoff, United States Military Academy
Grace A. Neff, California Polytechnic State University
Danielle Boyd Harlow, University of California at Santa Barbara
ABSTRACT:
In the past two decades, many undergraduate science programs have transitioned to a studio learning environment, where lecture and lab functions are integrated in the same time and space. This change is predicated on the assumption that students will learn better through more opportunities to interact as afforded by, in part, the physical design. In the General Chemistry studio studied here, student groups (such as lab partners) are collocated with other groups effectively constructing an additional interactional space (table group) not found in the traditional lecture and laboratory learning environments. However, few studies have researched the nature of the interactions between lab-partnered groups afforded by this formalized interactional space in a studio. Using and ethnographic perspective, this study addresses: 1) how this interactional space formalized in the studio learning environment affords students opportunities for learning and 2) what issues an instructor should consider for best preparing students to work in this environment. In this way, instructors may better support and promote desired social and cultural practices (interactions) to maximize opportunities for learning in these innovative learning environments.

The Effect of Contextual Instruction on Students' Motivation: A Study for Making it Relevant
Ceyhan Cigdemoglu, Atilim University
Omer Geban, Middle East Technical University
ABSTRACT:
The aim is to investigate the effect of context-based approach (CBA) over traditional instruction (TI) on students' motivation to learn chemistry and the effect of treatment on the factors of motivation. Six eleventh-grade classes with 187 students taught by three teachers from two public high schools were enrolled in this study. Each teacher had experimental and control group. These classes were assigned randomly as experimental and control. Chemistry motivation questionnaire was administered to groups before and after the treatment. The concepts of thermochemistry and thermodynamics were designed contextually for experimental groups and as usual for control groups. The treatment took almost eight weeks. First one-way ANOVA was used to compare groups, no difference across the groups was observed ($p = .102$). Then, MANOVA was used for revealing the effect of treatment on the factors of motivation. The results revealed that CBA was superior to TI on increasing students' intrinsic motivation to learn chemistry ($p= .014$) and relevance of learning chemistry to personal goals ($p= .001$). Further studies may design more lessons on different chemistry concepts to increase students' motivation to learn chemistry as a whole construct.

Predictors of Students' Meta-affective Inclinations in Chemistry Tasks
Esen Uzuntiryaki-Kondakci, Middle East Technical University
Zubeyde D. Kirbulut, Harran University
ABSTRACT:
The purpose of this study was to investigate the factors that predict students' meta-affective inclinations while they are studying for their chemistry classes. Considering the important role of affective components in learning and in an effort to understand the construct more meaningfully, we focused on meta-affect in this study. The

sample of the study consisted of 359 11th grade students from four high school students. Data were collected via Meta-affective Trait Scale (MATS) developed by researchers and Motivated Strategies for Learning Questionnaire (MSLQ) developed by Pintrich, Smith, Garcia and McKeachie (1991). In order to investigate the role of students' use of learning strategies, metacognitive self-regulation, and their self-efficacy for learning and performance in predicting students' meta-affective inclinations, two separate multiple linear regression analyses were conducted. Affective awareness and affective regulation were the outcome variables. The predictor variables were rehearsal, elaboration, organization, metacognitive self-regulation, and self-efficacy for learning and performance. Results indicated that elaboration and self-efficacy were significant predictors of affective awareness while metacognitive self-regulation and self-efficacy significantly predicted affective regulation. Discussion is provided.

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
Incorporating Science into Everyday Experiences
8:30am - 10:00am, Roosevelt
Presider: Sarah J. Carrier, North Carolina State University

Taking Science to the Outdoors
Tali Tal, Technion
Kara Haas, Michigan State University
Irene Bayer, Michigan State University
Joseph S. Krajcik, Michigan State University
Katherine L. Gross, Michigan State University
ABSTRACT:
In the outdoors, students can learn scientific ideas as well as practice science. Students can observe, explore, predict, raise questions and collect data through hands-on activities. Despite calls for increasing the learning of science in informal learning-environments, teachers face many challenges in outdoors teaching due to insufficient content and pedagogical content knowledge. Subsequently, we developed the "Teaching Science Outdoors" to establish long term relationships with a group of teachers, and support them throughout developing outdoor-inquiry learning units; use NGSS as guidelines for the development of school-based units; and use technology to teach inquiry outdoors. We followed the teachers' views of inquiry-based learning and of teaching in the outdoors before and after the PD, and aimed to understand the ways in which technology supported their learning. The teachers who were engaged in planning and doing outdoor inquiry aligned with NGSS were more inclined to teach inquiry in the outdoors. They highly supported the use of technology and felt they strongly improved their use of it. We believe that the PD structure and the content and support we provided could lead to further research on the integration of school-based and outdoor learning and on the integration of technology in learning outdoors.

Dramatizing the Authentic Research of a Local Scientist to Urban Elementary Students through Professional Theatre
Stephen R. Burgin, Old Dominion University
Jenifer Alonzo, Old Dominion University
Victoria Hill, Old Dominion University
ABSTRACT:
This paper focuses on the impact of a play that we developed in order to introduce elementary learners of an urban school to the research of a scientist working at a local university. The play was written in a way that might increase student understandings of nature of science, scientific inquiry, the identity of scientists, and the work that scientists do. We collected pre and post-play questionnaire responses and drawings of scientists from

third and fourth grade students who attended the play. We also interviewed a subset of their teachers. Findings indicated that most teachers felt strongly that their students had learned about scientific inquiry, the identity of scientists, and the work that scientists do as a result of attending the play. However, less than half of the student questionnaires and drawings of scientists indicated such growth as a result of the play. That being said, numerous students were able to tell us what they learned from the play and many questionnaire responses and drawings indicated such learning. Implications for partnerships between schools and university faculty from various disciplines in order to develop potentially impactful plays that portray authentic scientific research are discussed.

Family Learning Opportunities and Research in Science and Engineering
Amanda M. Gunning, Mercy College
Meghan E. Marrero, Mercy College
Zoila Tazi, Mercy College
ABSTRACT:
Quality time spent between parents and children can be a key predictor of students' academic success. As the achievement gap between underrepresented and dominant culture students continues to widen, this study sought to pilot a model for family learning to demonstrate how science is accessible to all and that parents can help to facilitate their children's science learning. The researchers conducted two "dinner meetings" in both English and Spanish in which parents and kindergarteners worked collaboratively through scientific investigations, and then applied their new knowledge out in the community. Through qualitative analysis of parent surveys, field notes and family science notebooks, we found that students' ideas about what science is and what scientists do shifted, as did the parents' beliefs about doing science with their children. This study uncovers important ideas that should be taken into account when designing family science activities for young children, e.g., that we should be explicit about parents' role as facilitators, and, for students, explicitly discuss what is meant by science and note when they are employing scientific practices.

Curriculum Planning and Enactment in Elementary Science: Beyond Fidelity of Implementation
Mandy Biggers, Penn State University
Cory T. Forbes, University of Nebraska-Lincoln
ABSTRACT:
Prior research shows that elementary teachers tend to rely on curriculum materials when teaching science. However, they often modify these instructional resources to emphasize certain scientific practices. Measures of fidelity of implementation provide evidence of how teachers enact curriculum materials, both in terms of adaptations they make and outcomes associated with such changes. However, few studies have investigated inservice elementary teachers' use of science curriculum materials. In this mixed-method study, we investigate empirical differences between teachers' lesson plans and enacted lessons using an observation protocol based on essential features of inquiry. In addition, we draw upon case studies of teachers to explain quantitative findings and describe specific adaptations to the curriculum as well as the teachers' pedagogical reasoning for their modifications. We found that elementary teachers did not make significant changes to their lesson plans for four out of five features of inquiry, but did engage students in the practice of communication more often in their enacted lessons than in their planned lessons. Three cases are presented as examples of the differing purposes and reasoning teachers had for their modifications. The study has implications for curriculum developers, professional developers, and classroom practice.

Community Based Engineering: An approach for Teaching and Learning in Urban Elementary Classroom Environments
Tejaswini S. Dalvi, University of Massachusetts, Boston
Kristen B. Wendell, University of Massachusetts, Boston

ABSTRACT:
We present a preliminary study investigating the feasibility of Community Based Engineering (CBE) modules for elementary schools within urban settings. We propose CBE as an innovative model, able to provide elementary students and teachers with meaningful experiences with the disciplinary practices of engineering and science within urban school settings. Our work recognizes two major needs, a) The Next Generation Science Standards' call for "the integration of engineering and technology into the structure of K-12 science education" (National Research Council, 2013) and b) the many challenges to teaching and learning in urban settings, that includes student populations with a wide range of academic preparation, and the often conflicting expectation to make educational activities relevant to students' lives outside the classroom (National Center for Educational Statistics, 2004). We attempt to answer these challenges by creating engineering teaching and learning opportunities that connect to the local community and encourage scientific concept exploration through the CBE modules. Our work positions engineering as a discipline to learn alongside science, starting early in elementary grades and attempts to integrate science, math and literature experiences within elementary urban school settings. The work presented is a part of the NSF funded CAREER project.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Related Paper Set - Leveraging the Epistemic Dimensions of Scientific Practice to Support Student's Meaningful Engagement in Modeling
8:30am - 10:00am, Columbus KL
Discussant: David Stroupe, Michigan State University

ABSTRACT:
Key to reform efforts, as articulated in NGSS, is for students to develop explanatory models of phenomena using evidence and use argument to evaluate, compare, and reach consensus on revised models. Meaningful practice requires that students understand what they are doing, how it will help them to achieve their scientific goals, and what counts as successful engagement. To help realize the reform vision and prevent these practices from becoming rote activities, we argue for moving beyond focusing on the structural aspects of scientific practice to focus on the epistemic dimensions, which include participants' 1) epistemic aim framing the activity; 2) the epistemic considerations guiding participants' scientific work; and 3) the degree to which students exhibited epistemic agency. In doing so, we focus not only on "how", but also on the "why". To frame our session, each paper will address the question, "How can attention to the epistemic dimensions of scientific practice help to support students' meaningful engagement in modeling?" The goal of our session is to provide an epistemic lens to examining how we can design professional development to help teachers align their instructional practice with NGSS and realize the reform vision.

A Comparative Longitudinal Case Study of the Use of Scientific Modeling in the Pedagogical Practice of Two Fifth-Grade Science Teachers
Joshua M. Rosenberg, Michigan State University
Christina V. Schwarz, Michigan State University
Silvia Wen-Yu Lee, National Changhua University of Education
Mete Akcaoglu, Georgia Southern University

Using Interactive Reflective Science Notebooks to Supporting Students Use of Modeling
Jeannette Manger, Wright State University
Lisa Kenyon, Wright State University

Examining the Teacher's Role in Supporting Elementary Students' Meaningful Engagement in Scientific Modeling

Li Ke, Michigan State University
Christina V. Schwarz, Michigan State University
Gail Richmond, Michigan State University

Learning to Support Students' Epistemic Agency and Meaningful Engagement in Modeling
Abraham Lo, Northwestern University

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Related Paper Set - Teacher Pedagogical Content Knowledge and Uses of Learning Progression-Based Curricula in Teaching Environmental Science Literacy
8:30am – 10:00am, Grand Suite 5
Presider: Alan R. Berkowitz, Cary Institute of Ecosystem Studies
Discussant: Alicia C. Alonzo, Michigan State University
ABSTRACT:
What do teachers need to know in order to use learning progressions effectively? In what ways do teachers take up and use learning progression-based curricula and associated teaching strategies? The four papers in this set address these and related questions through reports on research exploring teacher knowledge and practices in using learning progressions and learning progression-based curriculum materials in a multi-state research project on developing environmental science literacy. The project focused on three topic areas: carbon cycling, water cycling, and biodiversity. Utilizing assessments of teacher knowledge, surveys of teachers about curriculum materials, and video of teachers' instruction, these papers examine teacher uses of teaching strategies aligned with the learning progression approach, pedagogical content knowledge for using learning progressions, and implementation of learning progression-based curricular materials. Combined, these papers shed light on the nature of professional learning as teachers shift to use of particular teaching strategies when implementing learning progression-based curricula. These papers also provide insight into how teacher pedagogical content knowledge and understanding of learning progressions influence curricular implementation and, conversely, how using learning progression-based materials can support teachers in enriching their pedagogical content knowledge.

Using Learning Progression Frameworks to Inform Instruction in Environmental Science: Teachers' Efforts to Move Their Students Up Levels
Nissa Yestness, Colorado State Unviersity
Tobias Irish, Cary Institute of Ecosystem Studies
Julie A. Bianchini, University of California, Santa Barbara
Jiwon Kim, Michigan State University
LaTisha Hammond, George Washington University
Stacey Carpenter, University of California - Santa Barbara
Katherine Nilsen, University of California, Santa Barbara
Sylvia D. Parker, University of Wyoming
Alan R. Berkowitz, Cary Institute of Ecosystem Studies

Learning Progressions in Environmental Science: The Impact of a Professional Development on Teacher Practice
Tobias Irish, Cary Institute of Ecosystem Studies
Alan R. Berkowitz, Cary Institute of Ecosystem Studies
Sylvia D. Parker, University of Wyoming
Jennifer H. Doherty, University of Washington

Michele Johnson, University of California, Santa Barbara
Nissa Yestness, Colorado State Unviersity
Bess Caplan, Cary Institute of Ecosystem Studies
Laurel Hartley, University of Colorado Denver
Francis N. Clapp, Colorado State University
John C. Moore, Colorado State University

Science Learning Progressions, Discourse, and Teacher Pedagogical Content Knowledge
Shandy Hauk, WestEd and University of Northern Colorado
Kitty Roach, University of Northern Colorado
Nissa Yestness, Colorado State Unviersity
Joyce Kaser, WestEd
Alan R. Berkowitz, Cary Institute of Ecosystem Studies
John C. Moore, Colorado State University

Teacher Pedagogical Content Knowledge for Using Learning Progressions
Kristin L. Gunckel, University of Arizona
Beth A. Covitt, University of Montana
Aubrey Cano, University of California, Santa Barbara
Ivan Salinas, University of Arizona

Strand 5: College Science Teaching and Learning (Grades 13-20)
Reasoning and Problem-Based Learning in Physics
8:30am - 10:00am, Grand Suite 3
Presider: Luke D. Conlin, Stanford University

Perceptual Salience Influencing Undergraduate Students' Reasoning Resources on Introductory Physics Problems
Xian Wu, Kansas State University
Tianlong Zu, Kansas State University
Elise Agra, Kansas State University
N. Sanjay Rebello, Kansas State University
ABSTRACT:
Conceptual knowledge is only one part of what students need to learn to solve problems. Knowing how to reason through a problem is also an important skill. Research has demonstrated that perceptual salience can help students learn better than content with no perceptual salience. In this paper, we study the effects of a computer-based training featuring perceptual salience on students' reasoning on introductory physics problems. Participants (N=42) solved three sets of conceptual problems, each of them containing three isomorphic training problems with solutions followed, one near transfer problem, and one far transfer problem. We analyzed students' verbal answers to elucidate the reasoning resources that they activated to construct the different explanations to the problems. We found that the students changed their reasoning when presented with solutions to training problems and later posed a transfer problem. Our results provide insights into students' activation of their resources and the procedures they used to construct their reasoning in response to the training problems.

Investigating a New Approach in Undergraduate Physics Labs: Problem Based Cooperative Learning
Shane D. Bergin, School of Physics, Trinity College Dublin
Colette Murphy, Trinity College Dublin

Aoibhinn N. Ni Shuilleabhain, Trinity College Dublin

ABSTRACT:
This study introduced problem based cooperative learning (PBCL) to 1st year undergraduate physics labs and investigated the effect on students' understanding of the scientific method and on students' perception of their learning. The research incorporated one compulsory undergraduate physics lab for 200 students. 100 students took part in a traditional, manual-based lab to find the value of acceleration due to gravity and reported their findings following a conventional structure. The remaining students were assigned into small groups and were asked to find 'g' using any experimental approach they designed. These students presented their work within the lab for peer-review. At the end of term, each student completed an on-line survey, which incorporated student voice, following their participation in the lab and the generated qualitative data was analysed thematically. Students participating in PBCL reported more awareness of the scientific method, were engaged in their task, and their reflections highlighted the creative and collaborative nature of this active learning approach. Students following a traditional approach requested more exposition of content and assistance in compiling results, and reported far less engagement in the task. This initial study would suggest that participating in collaborative, cooperative, problem based learning is beneficial to undergraduate student learning.

Reasoning, Epistemology and Content Learning in College-level Introductory Physics

Lin Ding, The Ohio State University
Katherine N. Mollohan, The Ohio State University

ABSTRACT:
America's position at the forefront of research and innovation is a common talking point at the highest levels of government (e.g., Obama, 2011). At the same time, there is mounting interest in comparing students across state and national boundaries, particularly on measures of achievement. Concerns about the STEM workforce and attempts to understand and improve science education, writ large, are not singular to the US; they are shared by colleagues around the world. The main objective of this research is to develop surveys, collect and analyze data that provide an assessment of interest in STEM from university-level undergraduates, graduate students and faculty in the US and other countries among the leaders in areas related to STEM. The results presented here come from data collected during fall 2013 through spring 2014 at colleges and universities in China (n=1222 participants), the US (n=1505) and Australia (n=570). Generally, results indicate that classes at school are the most common experience reported across countries and times for triggering interest. . Books and magazines are commonly cited as one of the main sources of interest in China, are less common but oft mentioned in Australia, and are least commonly cited in the US.

Strand 6: Science Learning in Informal Contexts
Shifting Paradigms in Informal Science Institutions
8:30am - 10:00am, Gold Coast
Presider: Maritza Macdonald, American Museum of Natural History

Looking Back and Forward: Body Worlds as a Reflection of the Changing Science Centre

Michelle Dubek, University of Ontario Institute of Technology
Susan Jagger, Monmouth College
Erminia G. Pedretti, University of Toronto

ABSTRACT:
Body Worlds is an uncharacteristic display for a science centre. It harkens back to traditional museum exhibition design with mostly cabinets of curiosity rather than hands-on, interactive displays. While the exhibition itself is traditional in its presentation of science, its contemporary use of human cadavers as a medium to present health education is an illustrative example of how technology is evolving and in doing so

pushing the boundaries of scientific display. As science centres move into the 21st century, mandates and mission statements reflect their contributions to supporting a scientifically literate population. This paper describes what the Body Worlds exhibition conveys about the changing role of science centres and the nature of the exhibitions they display.

Impact of an Education Program in a Natural History Museum on Novice Learners' Evolution Knowledge and Creationism Beliefs

Kerstin Kremer, RWTH Aachen University
Anne Ahrens, Gymnasium Himmelsthür, Hildesheim
Julia C. Arnold, RWTH Aachen University

ABSTRACT:
This study aims at analyzing the influence of an education program in a natural history museum on fifth grade students' creationism beliefs. Therefore, we tracked knowledge gain and belief development with focus on biblical literalism of the novice learners over three test times before and after an one-day education program in a natural history museum. The study was carried out with 42 students (24 girls). Students visited the museum together with their biology teachers and participated in a program consisting of a guided tour an a fossil imprint activity. Data analyses were conducted using the item response theory (Rasch partial credit model) and classical test theory. The mean values of the person measures of knowledge and beliefs were compared over time. To test if the means differed significantly, ANOVA was calculated. A simple linear regression analysis was conducted to determine if creationism beliefs could be predicted from knowledge. The results show that evolution knowledge significantly predicted creationism beliefs. From the results we conclude that a knowledge initiated by an education program in a natural history museum can help novice learners to overcome non-rational creationism beliefs.

Transferring Cutting-Edge Research to Museum Learning Environments: Science in the Making versus Ready-Made Science

Marianne Achiam, University of Copenhagen
Bjørn F. Johannsen, University of Copenhagen

ABSTRACT:
School science differs considerably from the science of scientists. This is because in order to become teachable, science is taken from its original research context, deconstructed and reconstructed, and implemented in schools. While this transition is both necessary and inevitable, it may cause school science to become disembodied from its purpose or even obsolete. Accordingly, we suggest that museums are ideal places for the dissemination of cutting-edge science because they are not bound to school syllabi, they have immediate access to contemporary research, and they are already established as out-of-school resources. To examine this issue, we carried out a mainly qualitative study of the museum program DNA and Life. The program intended to engage secondary school students in authentic, cutting-edge research. Through targeted analysis of observations, video recordings, interviews and questionnaires with eight participating classes, we identified characteristics of the program that contributed to the authenticity of its activities, and also characteristics that detracted from it. We discuss these characteristics with regard to the rapid transition of the programme's content from the world of science to the world of education, and offer our perspectives on their implications.

Museum Exhibits and Curriculum Theory: Reflections from Autobiographical Writing

Ana Maria Navas Iannini, CTL-OISE-University of Toronto

ABSTRACT:
Science museums have undergone shifting paradigms associated to their identity, goals and practices. In this paper, I use autobiographical writing for examining some new trends in museum exhibitions. The meaning of three personal experiences related to science exhibits is explored through the lenses of curriculum theory,

particularly, through the work of reconceptualists. Moving from more traditional science exhibits to critical and controversial exhibits, I argue that the framework provided by reconceptualists enables powerful ways for theorizing around the role(s) of the subject matter, the notion of visitors and the educational goals of those exhibits.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers' Knowledge and Noticing
8:30am - 10:00am, Water Tower
Presider: Jamie N. Mikeska, ETS

Measuring Biological Knowledge and Personal Traits of Pre-service Biology Teachers
Yvonne Schachtschneider, University of Duisburg-Essen
Vanessa Pfeiffer, University of Duisburg Essen
Silvia Wenning, University of Duisburg-Essen
Angela Sandmann, University of Duisburg-Essen
ABSTRACT:
Current research shows evidence for a positive relationship between teachers´ content knowledge (CK) and students´ learning progress, as well as between CK and high-quality instruction. In addition, several studies provide evidence for CK as a precursor of pedagogical content knowledge. Therefore, CK is of particular importance in teacher education. Since university teacher education plays an important role in the acquisition of CK, the first step of teacher education at the university level should be the development of a solid base of CK. In our longitudinal study we focus on measuring first-year students´ biological knowledge and its development particularly with regard to their type of teacher education program and other individual characteristics. The findings can guide for the improvement of the quality of biological academic studies at university. The results show an increase of students overall performance from first to fourth semester. But there are no differences between pre-service teachers of different education programs. In the context of university success, students´ biological knowledge at university-entrance is associated with their performance in the basic lecture exams. Further relations with regard to biological knowledge, its development and relations to university success and student characteristics will be presented at the conference.

Shifts in Preservice Teachers' Noticing: A Cognitive Apprenticeship Model for Methods Courses Ideas
Dawnmarie Ezzo, Michigan State University
Amelia Wenk Gotwals, Michigan State University
ABSTRACT:
This embedded case study examines the extent to which pre-service teachers (PSTs) appropriate “practical tools” (Grossman et al, 1999) for noticing and incorporating elementary-aged students ideas into science instruction. Three PSTs in kindergarten classrooms and three PSTs in fifth grade classrooms were selected from an elementary science methods course. The course was structured using cognitive-apprenticeship model instruction (Collins, Brown, & Newman, 1989) on how to use tools for noticing student ideas and how to use these ideas to plan instruction. Examples of the PSTs’ noticing of student ideas during small group conversations and incorporation of those ideas into instruction were gathered before and after the cognitive-apprenticeship instruction. A constant comparative analysis (Strauss, 1997) of these examples revealed shifts in the PSTs’ noticing of student ideas and the incorporation of these ideas into their instructional plans. This suggests that, with appropriate support PSTs are able to notice nuances in student’ ideas and use these ideas in planning. Directed content analysis (Hsieh & Shannon, 2005) across all PSTs provides insight into some factors that influenced the PSTs’ appropriation of the tools. Awareness of these factors will enable teacher educators to develop PST education focused on supporting PSTs in developing these critical skills.

Preservice and Inservice Physics Teachers' Noticing and Teaching Modeling
Nam-Hwa Kang, Korea National University of Education
ABSTRACT:
Individuals view complex situations in a specific way. In particular, teachers' ability to notice important aspects of student ideas is crucial for providing meaningful instruction. The purpose of this study was to explore pre- and inservice physics teachers' modeling of teaching physics concepts based on what they had noticed in student ideas and thinking. Research questions included: (a) To what extent do pre- and inservice teachers notice details of student reasoning? (b) To what extent are pre- and inservice teachers' decisions on teaching moves connected to what they have noticed? (c) What are the differences in noticing and modeling of teaching between pre- and inservice physics teachers? A total of 59 pre- and inservice physics teachers participated in this study. To examine teachers' noticing in relation to student models, the teachers were given a scenario about a electric circuit. Given the scenario, the participants were asked to (a) interpret student thinking and (b) describe their planning of teaching moves to address student ideas shown in the scenario. The findings showed that both pre- and inservice teachers noticed underlying components of student models to some degree. However, in planning of teaching moves, not many participants took the student model into consideration. This was much worse among preservice teachers. Another notable result was a few preservice teachers' use of known instructional models in planning teaching unlike inservice teachers and other prservice teachers without any teaching experience. Based on the findings ways to support teachers' noticing skills and knowledge in teacher education were provided as well as further research topics.

Preservice Teachers Noticing Students' Scientific Thinking in Teaching Rehearsals
Amanda Benedict-Chambers, Missouri State University
ABSTRACT:
Given that the Next Generation Science Standards call on teachers to adopt an approach to science teaching that responds to student thinking, in this paper I argue that preservice teachers need to learn to notice. A teacher's ability to notice involves attending to facets of instructional interactions that shape student learning, and reasoning about those events to decide how to proceed. The purpose of this paper is to explore preservice teachers' noticing while participating in teaching rehearsals in a university-based elementary science methods course. This study investigated the following questions: (1) What do preservice teachers notice in discussions of teaching rehearsals? (2) How do preservice teachers reason about what they notice in discussions of teaching rehearsals? Three main findings emerged in the analysis: (a) participants collaboratively attended to science teaching and learning challenges related to student learning and students' use of scientific practices to explore phenomena; (b) participants articulated their thinking about the challenges; and (c) participants envisioned alternatives to the challenges in classroom contexts.

Strand 8: In-service Science Teacher Education
Related Paper Set - Transcending National Contexts: Cross-National and Comparative Science Education Research
8:30am - 10:00am, Columbus EF
Presider: Julie A. Luft, University of Georgia
Discussant: Peter Hewson, University of Wisconsin-Madison
ABSTRACT:
Despite the push for global science education, research in the field rarely transcends a single national context. To increase the knowledge in this area, this related paper set focuses on the theme of designing and implementing cross-national and comparative science education research studies. It draws upon an overall study that was collaboratively designed and implemented by researchers at sites in South Africa and the United States.

The participants included 16 beginning chemistry teachers from both countries. Each paper in the set focuses on a research project that was a sub set to the larger study. Paper 1 investigates the influence of policies on teachers' instruction. Paper 2 considers the support the teachers received in the countries. Paper 3 explores a model for science knowledge for teaching that can be applicable in different countries. Paper 4 compares the teachers' views and enactments of formative assessment. The value of the cross-national and comparative approach is addressed in each paper and involves the consideration of the global to local continuum. In addition, the collaborative design and implementation of the study encouraged dialogue across nations, which allowed researchers to consider local, national, and global factors that can influence science teaching and learning.

Helping Me Swim: Beginning Teachers' Reflections on Support in South Africa and the United States
Rene R. Toerien, University of Cape Town
Shannon L. Dubois, University of Virginia
Peter W. Hewson, University Of Wisconsin-Madison
Julie A. Luft, University of Georgia

Beginning Science Teachers' Views and Enactments of Formative Assessment in South Africa and the US
Melissa A. Jurkiewicz, University Of Nevada
Rene R. Toerien, University of Cape Town
Julie A. Luft, University of Georgia
Peter W. Hewson, University Of Wisconsin-Madison

Policy and Instruction: A Study of South African and United States Beginning Science Teachers
Shannon L. Dubois, University of Virginia
Rene R. Toerien, University of Cape Town
Julie A. Luft, University of Georgia
Peter W. Hewson, University Of Wisconsin-Madison

Science Knowledge for Teaching of Beginning Teachers in South Africa and the United States
Ryan S. Nixon, University of Georgia
Rene R. Toerien, University of Cape Town
Julie A. Luft, University of Georgia
Peter W. Hewson, University Of Wisconsin-Madison

Strand 10: Curriculum, Evaluation, and Assessment
Symposium - The Use of Adapted Primary Literature in Secondary Schools: From Theory to Practice
8:30am - 10:00am, Randolph
Presenters:
Anat Yarden, Weizmann Institute of Science
Moriah Ariely, Weizmann Institute of Science
Isabel Braun, University of Freiburg
Matthias Nueckles, University of Freiburg
Mesa B Davis, Georgia State University
Kadir Demir, Georgia State University
Galia Zer-Kavod, Weizmann Institute of Science
Jonathan Francis Osborne, Stanford University
Linda M. Phillips, University of Alberta
ABSTRACT:

Reading in science is one of the practices needed nowadays from a scientifically literate citizen. According to the K-12 framework for science education, engaging in critical reading of primary literature, adapted for classroom use, is one of the goals for achieving this practice. Adapted primary literature (APL) is an educational genre designed to enable the use of research articles in high-school. In this symposium we bring together researchers from Israel, Canada, Germany, and the USA, who investigate the use of APL for the teaching and learning of science. The goal is to provide a holistic overview and in-depth analyses of the use of APL in the context of basic and applied research studies. Thus, the presentations will evolve from a linguistic analysis of the various text genres, to experiments that were carried out in laboratory-settings, to analysis of the use of various text genres in class, and closing with the pedagogical content knowledge that is required for teaching using APL. We would like to dedicate all the presentations and discussions in this symposium to Stephen P. Norris, who untimely passed earlier this year and had an influential impact on our work.

Strand 11: Cultural, Social, and Gender Issues
Symposium - Culture, Language, Practices, Place in STEM Education: Indigenous and Place-based Approaches from Pacific and Americas
8:30am - 10:00am, Columbus GH
Discussant: Steven Semken, Arizona State University
Presenters:
Pauline W. U. Chinn, University of Hawaii - Manoa
Steven C. Semken, Arizona State University
Irasema Ortega, University of Alaska-Anchorage
Tara B. O'Neill, University of Hawaii
Flora Ayuluk, Kashunsmint School District
Sandra C. Londono, Arizona State University
Megan Bang, University of Washington
Huihui Kanahele-Mossman, Ka Umeke Kaeo
Sharon Nelson-Barber, WestEd
David B. Zandvliet, Simon Fraser University
ABSTRACT:
This symposium presents the ways Indigenous and local, place-based issues and perspectives influence curriculum development, pedagogy, teacher education, research and assessment. Overall, 83% of all U.S. public and private school teachers report being "white, non-Hispanic" thus may be unfamiliar with the lives and cultures of increasingly diverse students. Meanwhile secondary STEM educators continue to be prepared within subfields of science, mathematics and technology. The National Research Council's A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas recommends that "learning...in the physical, life, earth, and space sciences and engineering should be strongly linked with parallel learning in the social, behavioral, and economic sciences" but most teachers work in self-contained classrooms apart from colleagues and communities outside of school. The isolation teachers experience is highly problematic given the underrepresentation of minorities in STEM fields and pressing concerns surrounding the sustainability of social ecological systems. Whether the concern is consumerism, global competition, or climate change, science education must prepare all students to understand and address complex problems in more integrated, nuanced ways. This symposium generates cross-cultural understandings, inspires relationship-building, and encourages action towards a vision of science literacy for all learners.

Strand 12: Educational Technology
Cognitive and Metacognitive Support Tools

8:30am - 10:00am, Columbus AB
Presider: Corey E. Brady, Northwestern University

Computational Thinking in the Science Classroom: Preliminary Findings from a Blended Curriculum
David Weintrop, Northwestern University
Kai Orton, Northwestern University
Michael S Horn, Northwestern University
Elham Beheshti, Northwestern University
Laura Trouille, Northwestern University
Kemi Jona, Northwestern University
Uri Wilensky, Northwestern University
ABSTRACT:
Computation is changing the way modern science is conducted, but relatively few students have access to or take courses that adequately prepare them for the increasingly technological nature of these fields. Further, the students who do study computational topics tend to not reflect the greater student body, with female and minority students being disproportionately underrepresented. To address this issue, we propose embedding computational thinking content into high school science coursework. This paper presents initial findings showing that despite significant gaps in attitudes and confidence between male and female students towards science and computational thinking, no difference in aptitude between genders was found. Additionally, female students who participated in the project showed improved confidence with computational thinking and interest in scientific fields.

Visualizing Energy and Matter Transformations for Linguistically Diverse Students
Kihyun (Kelly) Ryoo, University of North Carolina, Chapel Hill
Kristin Bedell, University of North Carolina, Chapel Hill
ABSTRACT:
New visualization technologies have the potential to improve science learning for all students, including English Language Learners (ELLs), by explicitly depicting the continuous processes of dynamic systems. However, how different forms of visualizations on ELLs' understanding of complex scientific phenomena have not been explored yet. This research investigates how dynamic visualizations, compared to static visualizations, can support ELLs and English proficient students (EPSs) in developing an integrated understanding of energy and matter transformations at the molecular level. 73 ELLs and 75 EPSs in each classroom were randomly assigned to either a dynamic or a static visualization condition and completed a web-based inquiry unit featuring dynamic visualizations or static visualizations of energy and matter transformations for 12 days. The results show that dynamic visualizations were significantly more effective in helping both ELLs and EPSs developing a sophisticated understanding of how energy and matter transform and linking these ideas to the processes of photosynthesis and cellular respiration, compared to static visualizations. This study suggests that it is possible to design effective dynamic visualizations that can enhance all students' science learning in linguistically diverse mainstream classrooms.

Adding Computational Thinking to your Science Lesson: What Could it Look Lke?
Jennifer L. Albert, NC State University
ABSTRACT:
The Next Generation Science Standards (2013) call for computational thinking to be a key practice in science education. However, educators have found this to be a difficult task. Studies have shown that a set of conditions must be met for computational thinking tools to be used in K-12 education and that when they are used, there is a wide spectrum in the level of computational thinking that the tool requires. This study extends this work by examining how middle school students translate their science fair projects in Scratch and what evidence of

computational thinking is present. Scrape, a tool designed to analyze Scratch projects was used. Overall, it was found that most students simply created a presentation of their project without much complexity. Eight students created interactive projects that required user participation and used more advanced computational concepts. This suggest the ability to document and begin to assess students' computational thinking in a science education context.

Strand 12: Educational Technology
RP-Set – Science Needs a Marketing Make-Over: Playful Learning in Formal and Informal Science Education
8:30am - 10:00am, Wrigley
Discussant: Len Annetta, George Mason University
Presenters:
Denise M. Bressler, Learning Edge Ventures
Alec M. Bodzin, Lehigh University
Stephen Slota, University of Connecticut
Heather Toomey Zimmerman, Penn State University
Susan M. Land, Penn State University
Dana Atwood-Blaine, University of Kansas
Douglas W. Huffman, University of Kansas
Len Annetta, George Mason University
ABSTRACT:
In 2012, the National Research Council published A Framework for K-12 Science Education and highlighted that "by the end of 12th grade, all students [should] have some appreciation of the beauty and wonder of science" (p. 1). The report explained that—unfortunately—our educational system is not achieving that outcome due to overemphasis on discrete facts and lack of engaging, authentic experiences. The papers in this set represent a selection of both formal and informal science activities that are engaging and authentic, ranging from an outdoor mobile activity to place-based mobile games to an alternate reality game. These projects go far beyond isolated facts: they aim to offer breadth and depth. This paper set is comprised of concrete examples for how we can give science a marketing make-over, helping students to perceive the wonder and beauty of science through playful learning. Overall, this paper set will focus on: 1) research projects that present science education as more than isolated facts by emphasizing the wonder of science; 2) examples of experiences that create engaging contexts for science content; and 3) results that demonstrate the effectiveness of well-designed playful learning experiences.

Strand 14: Environmental Education
Environmental Research in Post-Secondary Education
8:30am - 10:00am, Grand A
Presider: Lene Møller M. Madsen, University of Copenhagen

Expressions of Dynamic and Cyclical Thinking among University Students in the Context of Earth Systems
Orit Ben Zvi Assaraf, Ben-Gurion University of the Negev Israel
Or Batzri, Ben Gurion University of the Negev, Israel
Nir Orion, Weizmann Institute of Science
Carmit Cohen, The Dead Sea-Arava Science Center (DSASC)
ABSTRACT:

Geoscience plays a crucial role in the development of holistic systems thinking. System thinking is a tool for developing a deeper understanding of the system's characteristics and behavior. Our study is innovative in that it examines the expression of two important system thinking characteristics – dynamic thinking and cyclic thinking – amongst students in higher education institutes. In this quantitative study, students were asked to note the extent of their agreement with statements on a Likert scale. The research group (n=223) included students majoring in geology, or minoring in it along with physical geography. The control group (n=312) included students with no background in geology (life sciences, engineering, computer science and economics). The students in the research group expressed higher levels of dynamic thinking than the control group. While the geology students showed relatively strong dynamic thinking towards the geosphere and hydrosphere, this was not the case for the biosphere. The geology students showed significantly higher levels of cyclic thinking than the other sub-groups, for all Earth systems, suggesting a connection between learning about different cycles in Earth systems, developing cyclic thinking and applying it to other Earth cycles.

Impact of Socioscientific Issues Instruction on Students' Conceptions about Contentious Greater Yellowstone Area Environmental Issues

Benjamin C. Herman, University Of South Florida
Mark Newton, University of South Florida
Dana L. Zeidler, University of South Florida

ABSTRACT:
The purpose of this investigation was to examine the extent SSI instruction embedded in a six week experiential environmental issues course in the Greater Yellowstone Area (GYA) facilitated 24 post-secondary students' abilities to engage contentious environmental issues (CEI). A mixed methods pre – post design was used and data sources collected before and after the experiential environmental issues course included a modified Character and Values as Global Citizens Assessment (Lee et al., 2013) which measured Ecological Worldviews across the dimensions of Interconnectedness, Sustainable Development, Moral and Ethical Sensitivity, Perspective Taking, Empathetic Concerns, Feeling of Responsibility and Examining Scientific Evidence through Likert choices and qualitative prompts with follow-up interviews. Findings showed that the participants' course experiences influenced them to feel more accountable for CEI and increasingly believe humans should sustain nature, but that human development will unlikely be equally beneficial for humans and nature. Moreover, after course completion the students better understood that effective CEI resolution requires weighing scientific evidence in juxtaposition with sociocultural and ethical considerations. Implications and pedagogical considerations addressed include effectively embedding SSI instruction within experiential environmental education in a manner that will help develop scientifically and culturally literate citizens that can effectively engage in socioscientific decision-making.

Determining Essential Components of a College-level Bioenergy Curriculum Using the Delphi Technique

Kimi Grzyb, Oregon State University
Brian Hartman, Oregon State University
Katharine G. Field, Oregon State University

ABSTRACT:
In order to develop bioenergy into a viable industry capable of providing valuable amounts of energy and employment, there is an immediate need for a workforce whose education combines interdisciplinary content knowledge with integrated approaches to innovation and problem solving. To meet this need, it is necessary to identify and prioritize the topics that should be included in a college-level bioenergy curriculum. A three-round Delphi study was implemented to establish consensus among a panel of bioenergy experts. Round 1 consisted of a single open-ended question: Keeping in mind the future of a commercial bioenergy industry, what content knowledge should a student have upon completion of a college-level bioenergy curriculum? Results from round 1 were qualitatively coded, resulting in 14 themes. In round 2, experts were asked to rate the importance of

including each theme using a 5-point Likert-type scale (1=Non-essential to 5=Essential), and twelve of the 14 themes were rated ≥4 out of 5. Round 3 will determine final expert panel consensus and stability. Results will be used to bolster the existing bioenergy education initiative at (removed to maintain anonymity) and provide guidance to other institutions interested in developing similar bioenergy education programs.

Learning about Resilience and Systems: A Case Study of a Natural Resource Management Student

Anne Marie Casper, Colorado State University
Meena M. Balgopal, Colorado State University
Maria E. Fernandez-Gimenez, Colorado State University

ABSTRACT:
Natural resource management (NRM) students need to have well developed system thinking knowledge and skills, as well as strong communication and group work skills to articulate their ideas and collaborate with others. Currently, many NRM students are not graduating with these skills. We used conceptual change theories and Gee's Discourse analysis theory as a lens for a case study analysis of one recent student of our NRM capstone class to address the questions: how does a NRM capstone class impact students' interpersonal and disciplinary skills? How are these skills necessary for developing expertise in resilience and systems thinking? From a semi-structured interview, we found that space, time, and holism influenced both the participant's perception of the learning environment, as well as his conceptions of resilience and systems thinking. His ideas of systems thinking and resilience broadened to encompass greater complexity and a more dynamic nature. His conceptual change was influenced by the interactions with other students, professionals, and stakeholders during class, as well as long-term engagement in a semester-long group project. The conceptual change this student demonstrated indicates that large conceptual shifts can occur in a capstone class. This pilot study will inform the interventions for our full study.

Strand 15: Policy

Elementary Science Education in the Context of Contemporary Educational Policies

8:30am - 10:00am, Columbus IJ

Presider: Sherry A. Southerland, Florida State University

Changing Elementary Teaching Roles: Teacher Specialization in the Wake of the STEM Movement

Susan Poland, George Mason University
Kristofer Pachla, George Mason University
Amanda Luh, George Mason University
David E. Long, George Mason University

ABSTRACT:
Recent public interest in student academic performance has placed a great deal of pressure on US schools at all grade levels. This pressure has been particularly difficult for elementary school teachers who are expected to teach all core subject areas with fluency. In the wake of this pressure, some schools have asked elementary teachers to "specialize" in one or two content areas in an effort to increase student performance and reduce teacher workload. Through interview data, we reflect on the pros and cons of specialization and generalization, as told by teachers who have worked in these settings. Our data does not provide a prescriptive policy for or against specialization. Rather, our data suggests that the specialist and generalist teaching formats can be equally effective with administrative support and proper teacher training.

Title I Status, the Accountability Movement, and Time for Science in Elementary Schools

Cheryl O'Connor, George Mason University
Andrew J. Keck, George Mason University

David E. Long, George Mason University
ABSTRACT:
Elementary school teachers strive to make the most out of the limited time they are given with students, but decisions about the time allotted for enactment of the curriculum are influenced by many factors. Control of lesson time is one of the many factors essential to teachers running a class, but often not in direct control of the teachers themselves, limiting the scope, quality and depth of their lessons. This study addresses the variable impact of federal and state accreditation status, Title I status, and whether either or both have any effect on the allocation of time for science in elementary classrooms. This study used data obtained from interviews with elementary teachers associated with a state-wide science professional development program. The influences of testing requirements and high-stakes consequences of that testing on elementary science time allocation do not follow a clear pattern based on Title I and accountability status but can affect how teachers describe related decisions in their schools.

Supporting Elementary and Middle School STEM Education: A Literature Review
Ashley Chiu, Museum of Science and Industry, Chicago
Aaron Price, Museum of Science and Industry, Chicago
Elsie Ovrahim, Museum of Science and Industry, Chicago
ABSTRACT:
The Framework for K-12 Science Education (National Research Council, 2012) puts an enormous responsibility upon our education system to achieve numerous student outcomes. A fundamental approach is needed to support the movement to incorporate STEM into classroom and schools with success. This poster describes a review of the research literature about the best practices of STEM education at the K-12 level. More specifically, what school components support successfully integrated STEM education and characteristics of effective STEM programs that succeed in delivering quality STEM education. The Next Generation Science Standards is placing more of an emphasis upon science education at the elementary and middle grades, paving the way for new avenues for research. In our literature review, we found a few fundamental, yet consistent suggestions about how to support STEM education in K-8 schools. Our review provides a synthesis of the evidence-based research as a quick reference to support research-based decision-making at the classroom and school administration level and highlight directions for future research. The review is in support of a museum-based project to create a framework for supporting schools, teachers, and administrators in delivering quality science education.

Pedagogical Choice in Elementary Science Education: Testing Explanatory Variables
Kathryn N. Hayes, California State University, East Bay
ABSTRACT:
Considerable research has focused on science pedagogies, resulting in a robust, if debated, understanding of best pedagogical practices. Yet, exposure to excellent science instruction in elementary school is haphazard at best, and often inequitable. Although the research community has attended to the role of teacher factors, such as attitude and preparation, in science education practice, very little research attends to policy or school level factors in constraining or supporting such best practices at the elementary level. This study attempts to fill this critical need through a multi-level model of how teacher attributes and school and policy factors predict the opportunity for hands-on science education. Results indicate an inequitable distribution of hands-on science; high poverty students received substantively less hands-on science education. Accountability pressure eclipsed all other predictors, including socio-economic context, in accounting for variance in the model. Teacher factors such as professional development, experience, and degree were insignificant in the model. This has implications for efforts to improve elementary science education in the United States, as research and national priorities have up to this point been focused primarily on teacher development.

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

Publications Advisory Committee Sponsored Session
Symposium - New Horizons for the Journal of Research in Science Teaching
10:15am - 11:45am, Water Tower
Presenters:
Fouad Abd-El-Khalick, University of Illinois
Dana L. Zeidler, University of South Florida
ABSTRACT:
The purpose of this symposium is to provide an interactive forum for NARST members to help contribute to the future directions and policies of JRST. Our vision for JRST is guided by three broad themes: 1) fostering science education as a global endeavor; 2) building broad scientific literacy and engagement, as well as bolstering the health of national and global scientific pipelines; and 3) issues of social justice, equity, and diversity in science education including access to science and the scientific enterprise. Three closely associated and equally central domains to this vision are: (a) Increasing JRST's impact on policy, (b) publishing scholarly works focused on conceptual and theoretical analyses, along with empirical works, and (c) building into JRST's mission a significant educational component focused on developing capacity among graduate students and JRST reviewers toward preparing the next generation of researchers, as well as JRST reviewers and associate editors. After a presentation of these themes, participants will have the opportunity to engage in smaller group discourse lead by members of our new team of Associate Editors. The generation of novel ideas will be synthesized and reported back to the larger group for future consideration.

Administrative Sponsored Session
Symposium - Characterizing Quality Research in Engineering Education
10:15am - 11:45am, Grand A
Presenters:
Marie-Claire Shanahan, University of Calgary
Cathy Lachapelle, Museum of Science, Boston
ABSTRACT:
This session, co-sponsored by the Engineering Education RIG and the Research Committee, will address issues of quality (equitable, transformative, and creative) research with potential to create broad impact on STEM education globally. It will focus in particular on the special challenges and potential of engineering education research, including methodological constraints and cultural norms (e.g., the emphasis placed on career orientation in much STEM rhetoric). A panel of engineering education researchers from qualitative, quantitative, and mixed-methods research traditions will discuss a series of questions including: What does equity research mean in engineering education? What is important to measure about engineering learning and learning through engineering? How do we judge the success of educational interventions? What does engineering education research look like outside of career awareness and development? How can qualitative research inform engineering education?

Strand 1: Science Learning, Understanding and Conceptual Change
Emerging Issues in Conceptual Change
10:15am - 11:45am, Grand Suite 5
Presider: Mehmet Aydeniz, The University of Tennessee

The Use of Metacognitive Tools to Support Model Development in High School Physics

Ozden Sengul, Georgia State University
Katherine S. Wade, Coretta Scott King Young Women's Leadership Academy
Abdulkadir Demir, Georgia State University
Azhar M. Qureshi, Georgia State University
Ozden Sengul, Georgia State University

ABSTRACT:
The use of different teaching strategies is important to elicit students' prior knowledge and change their existing conceptions to scientific conceptions. In order to create conceptual change, students need to develop metacognitive skills by being aware of their thinking and developing reflective practices from their learning experiences. Therefore, in this study, we focused on the examination of teaching for conceptual change methods using modeling while teaching Ohm's Law in a high school physics class. This study was carried out to explore how modeling instruction can be implemented as a metacognitive tool to help Ohm's Law and increase students' learning gains. We used a mixed method approach, which makes use of qualitative data primarily, specifically interviews and students' reflections, and quantitative data in the secondary role as pre- and post-tests. Preliminary results show that the use of metacognitive tools increased students' understanding of content and depth of knowledge. Moreover, in terms of pre- and post-test scores, there was no significant difference between the treatment and control groups, but there was a difference in depth knowledge and ability to apply knowledge to answer questions. Students in treatment group developed metacognitive skills by allowing them to support their answers appropriate evidence and reasoning.

Facial Microexpression State decision Tree for Conceptual-Conflict Based Conceptual Change

Mei-Hung Chiu, National Taiwan Normal University
Yuh-Ru Yu, National Taiwan Normal University
Hongming L. Liaw, National Taiwan Normal University
Chin-Cheng Chou, National Taipei University of Education

ABSTRACT:
The current study attempted to apply the decision tree methodology in the prediction of the probability of student conceptual change based on students' facial microexpression states (FMES). Conceptual change through conceptual conflicts in science education is a well-studied field. There is, however, little research done on conceptual change through conceptual conflict in terms of students' facial expressions. As facial expression are one of the most immediate and direct responses one can get during instruction and that facial expressions are often representations student's emotions, a link between students' FMES and learning was explored. Through adopting the decision tree methodology, the current study was able to present a way to better predict the likelihood of students undergoing conceptual change in scenarios where conceptual conflicts were adopted as a medium.

Theoretical and Practical Implications of Implicit Learning for Science Education and Conceptual Change

Jeremy Y. Wang, University of Minnesota
Keisha Varma, University of Minnesota

ABSTRACT:
In this conceptual paper, we discuss how psychological theory and research on implicit learning can be leveraged in science education research, particularly in relation to conceptual change. We advance the argument that implicit learning processes play an important role in the development of students' prior knowledge of scientific phenomena. After defining and providing a brief overview of research findings on implicit learning, we explore theoretical and practical implications for science teaching and learning, offering predictions and methodologies for future research.

Concepts, Conceptual Metaphor and the Study of Conceptual Change
Tamer G. Amin, American University of Beirut
ABSTRACT:
Recently, a body of literature has begun to emerge that is drawing on the cognitive linguistic theory of conceptual metaphor to analyze scientific language and problem solving, characterize and identify the source of student conceptions, and design instructional interventions. However, this literature has not been guided by an explicit, unified perspective. A clearly articulated theoretical perspective would help unify the interpretation of disparate studies and suggest follow up research studies, turning this body of work into a programmatic scientific effort. Various theoretical perspectives on concepts and conceptual change do already exist in the science education literature. Over the last two to three decades, two perspectives have dominated: the "coherence" and "knowledge-in-pieces" perspectives. However, the empirical findings of the work drawing on the notion of conceptual metaphor suggest that additional constructs are required. In this theoretical paper, a view of concepts is outlined that draws on elements of both the coherence and knowledge-in-pieces views, and incorporates a role for conceptual metaphor in the representation of concepts. It is argued that the proposed perspective generates novel questions for further research into student conceptions and how to design instructional interventions.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set - Ag-STEM: Re-Emphasizing Agriculture Connections with STEM for Contextualized Teaching and Learning
10:15am - 11:45am, Columbus GH
ABSTRACT:
Recent efforts in science education reform have called for the integration of technology, engineering, and math (STEM), especially via cross-cutting concepts and the contextualization of these topics in real-world, authentic problems. One context that also naturally integrates the four STEM domains is agriculture. The papers presented here aim to introduce efforts from the agricultural education community to our STEM education colleagues, by describing studies on and designs for Ag-STEM education for a variety of audiences and settings. The first paper explores how to make interdisciplinary collaborations in research and practice a reality. The second paper examines the necessary tools and resources for well-equipped Ag-STEM laboratories to promote teacher self-efficacy and student learning. The third paper discusses perceptions of teachers and 4-H agents of the role of agricultural education in the STEM movement. Finally, the last paper describes how public audiences define agriculture and science, terms which researchers and practitioners recognize are connected.

STEM in an Agricultural Context: Exploring Interdisciplinary Collaboration
Matt Spindler, Virginia Tech

Utilizing a Delphi Study to Establish The Teaching Resources Needed For an Ideal Post-Secondary Applied STEM (Agricultural Mechanics) Learning Laboratory
J. Chris Haynes, University of Wyoming
Bart E. Gill, Delaware Department of Education
Ryan Anderson, Iowa State University

What does Ag-STEM Mean for Me? Perceptions of Teachers and 4-H Agents
Hannah Scherer, Virginia Tech

Do they See a Connection? Public Definitions of Science and Agriculture

Kathryn A. Stofer, University of Florida
Milton G. Newberry III, University of Florida

Strand 3: Science Teaching--Primary School (Grades preK-6): Characteristics and Strategies
STEM, STEAM, and Literacy: Learning from Practice
10:15am - 11:45am, Columbus EF
Presider: Jamie N. Mikeska, ETS

Building a Successful University and School Partnership for STEAM Education: Lessons from the Trenches
Bhaskar Upadhyay, Uniersity of Minnesota
Kara Coffino, University of Minnesota
John Alberts, Austin Public Schools
Andrew M. Rummel, University of Minnesota
ABSTRACT:
This paper looks at the nature of successful school partnership culminating in a successful STEAM program in a 5th/6th grade school. The data were collected over two years during the professional development days through videotaping, interviews and observations. A successful STEAM implementation at the school level can be achieved through strong commitment from both the leadership team and the teachers. The paper shows that a successful STEAM partnership and implementation hinges on four core outcomes: 1. Attending to the non-cognitive features of STEM Education; 2. Letting teachers experience what the students experience in the classroom; 3. Inquiry as access point for disciplinary teachers into the Engineering process; and 4. Building leadership capacity

STEM Program Characteristics in an Elementary School.
Richard L. Lamb, Washington State University
Rebekah Lamb, Washington State University
Kaylan Petrie, Washington State University
ABSTRACT:
Students within the United States struggle to maintain an adequate position within the context of international testing and competitions in STEM subjects. Researchers selected two-hundred and fifty four students for this study, from grades, K, 2 and 5. Student ages range from 5-years old to 12-years old. Grade and age progressions, allow for a cross sectional analysis of STEM program intervention effects. Review of quantitative results suggests that there are significant differences in affective and cognitive measures between the control and intervention school.

The Importance of STEM Education in the Elementary Grades: Learning from Preservice Teachers' Perspectives
Lauren Madden, The College of New Jersey
James Beyers, The College of New Jersey
Steve O'Brien, The College of New Jersey
ABSTRACT:
Studies show that instructional time dedicated to science and STEM lags behind language arts and mathematics at the elementary level. In an effort to better predict how this trend might continue in the future, we seek to understand how preservice and novice teachers view the importance of STEM education in the elementary grades. A sample of prospective elementary teachers enrolled in (or recent graduates of) an undergraduate teacher education program who have all completed courses in mathematics and science methods, were surveyed using an anonymous online questionnaire. The questionnaire asked for descriptive information and one open-

ended question: “Is STEM education important at the elementary level? Why or why not?” A thematic qualitative approach was used to analyze responses. We found that all participants responded that yes, STEM education was important at the elementary years, but that several themes emerged when considering reasons given, and that the types of responses given varied in terms of subject and complexity when comparing responses by respondents’ second major. These findings paint an initial picture of what future elementary STEM instruction might look like, and help us to offer suggestions for pre- and inservice teacher education.

Design-Based Research Approach for Integrating Science and Literacy in Elementary Classrooms
Xavier Fazio, Brock University
Tiffany L Gallagher, Brock University
ABSTRACT:
Our paper presents findings from a design-based research study based on an integrated physical science and literacy curriculum for elementary classrooms. Grade 5 teachers and science education researchers co-constructed pedagogical knowledge for science and literacy integration, and designed instructional resources for students' learning physical science concepts through an integrated unit titled 'Properties and Changes in Matter'. Using qualitative methods and analyzing student and teacher artifacts our results identified themes illustrating the effectiveness of using design-based research. Three major findings included: the value of collaboration for teacher development; teachers' evolving understanding of integration in science and literacy; and, the importance of feedback through classroom implementation. This study will resonate with educators who both facilitate and participate in professional learning communities and meaningful collaboration regarding curricular integration of science and literacy. Recommendations are offered for elementary science teachers and researchers using design-based research for curriculum and teacher development. This study is of interest to researchers studying elementary teachers' pedagogical practices focused on integrated science and literacy learning in the context of the Next Generation Science Standards reforms.

Examining Language Expectations and Supports during Elementary Science Instruction.
Karl G. Jung, University of Minnesota
ABSTRACT:
For many students, school requires them to use language in new ways, that differ from the ways they use and experience language outside of school. Science teaching and learning presents some of the most challenging language for students, as it contains complex jargon and structures that differ greatly from everyday language use. Students also need to gain access to the general academic vocabulary and structures necessary for accomplishing tasks in school. This qualitative study investigates teacher expectations for student language use during elementary science instruction in a 4th grade classroom, as well as the supports that the teachers provided for students in meeting that expected language use. Findings show a focus on the content specific vocabulary related to science teaching, without providing students with explicit instruction into the general academic vocabulary or language structures necessary to complete the identified language objectives.

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Symposium - Developing, Refining, and Sustaining the Next Generation of Responsive Science Teaching
10:15am - 11:45am, Comiskey
Presenters:
Angela Calabrese-Barton, Michigan State University
Leema Berland, University of Wisconsin-Madison
Melissa Braaten, University of Wisconsin-Madison
Paul Hutchison, Grinnell College
Hosun Kang, University of California Irvine

Daniel Levin, University of Maryland
Melissa Luna, West Virginia University
Rosemary Russ, University of Wisconsin-Madison
Christina V. Schwarz, Michigan State University
Jessica J. Thompson, University of Washington

ABSTRACT:
For many science educators, the ideas, interests, experiences, and pursuits of young students are central for creating meaningful learning environments. However, creating learning environments responsive to students' ideas, experiences, language, and culture has proved elusive for novice and experienced educators alike. Responsive teaching – where teachers and students notice, attend, interpret, and respond to other students' contributions –holds students' contributions at the center of classroom practice. Despite general consensus that is a worthy goal, we have not yet specified robust conceptions of what responsive science teaching entails nor have we determined successful ways to support teachers as they work to become more responsive across their careers. This symposium brings together 10 scholars representing 7 different institutions across the U.S. who are tackling some of the challenges of developing, refining, and sustaining the next generation of responsive science teaching. By bringing together differing theoretical commitments across multiple research projects united in a focus on facets of responsive science teaching, this symposium will open up debate and invite audience members to weigh in on central concepts facing our shared endeavor of fostering responsive science teaching.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Instructional Practices - Biology
10:15am - 11:45am, Columbus AB
Presider: Stephanie B. Philipp, Miami University

Evaluating a Network of Scientists and Educational Specialists Developing Standards for Experimental Design in Biology

Yue Yin, University of Illinois at Chicago
Nancy J. Pelaez, Purdue University
Stephanie Gardner, Purdue University
Trevor R. Anderson, Purdue University

ABSTRACT:
This study explored and evaluated a network among scientists and educational specialists to develop the standards for biology undergraduate students. In particular, this study explored the collaboration among scientists and educational specialists and examined whether scientists and educational specialists learn from their collaboration and achieve expected collaboration goals. Preliminary analyses show that overall scientists and educational specialists (a) agreed that we need to improve the instruction and assessments of biological experimentation, (b) increased their self-rated knowledge about biological experimentation through their collaboration, (c) were satisfied with the effectiveness and experience of their collaboration.

The Effect of Engaging Science Programs on Undergraduates' Educational Experiences

Zehavit Kohen, Technion
Dan Perlman, Brandeis University
Yehudit Judy Dori, Technion-Israel Institute of Technology

ABSTRACT:
Educators only infrequently study the long-term impacts of educational experiences. This study explores the self-reported effects of active learning environments (ALE) on students up to 24 years after such experiences.

This study aims to: (a) investigate the impact of educational experiences during ALE courses on undergraduate students; (b) explore lasting impacts of these experiences on students' preparation for and motivation toward specific careers and/or professions. Research participants included: 1) 73 Former undergraduate students who had taken two or more Environmental Studies courses over the previous 24 years; and 2) 88 Current students in an introductory Environmental Studies course. Many participants reported gaining knowledge, skills and attitudes, which are important for their future professional work. In our study, the lasting impact was investigated according to the self-reported intensity of the educational experience and the time elapsed since the end of the course or the undergraduate program. The impact of these educational experiences was especially significant for former students, many of whom described direct links between their learning in these courses and their subsequent professional work. We expect that current students who experienced a strong intensity in an introductory Environmental Studies course will choose to engage in this field in the future.

Doctoral Biology Training and Proposed Threshold Concepts
Christopher Rates, University of Virginia
David Feldon, Utah State University
ABSTRACT:
This study explored potential threshold concepts within biology graduate education. Doctoral students, postdocs, and assistant professors (N=40) were interviewed about core competencies that students develop during graduate education and which they felt might function as threshold concepts. Using a combination of analytic induction and constant comparative analysis, categories of potential threshold concepts were created from the transcribed interviews. Four potential threshold concepts included Primary Literature, Hypotheses, Research Questions, and Controls. Findings from this study extend the work of Kiley and Wisker (2009) into graduate biology education and lay the framework for future research to better understand the developmental trajectory of these threshold concepts in order to create more effective training programs.

The PCK of Biology Faculty at Large Research Institutions
Kathleen Hill, Bethany College
ABSTRACT:
To address the need of scientists and engineers in the United States workforce and ensure that students in higher education become scientifically literate, research and policy has called for improvements in undergraduate education. One pathway for improving undergraduate education in the science fields is to reform undergraduate teaching. Only a limited number of studies have explored the pedagogical content knowledge of postsecondary level teachers. This study was conducted to characterize the PCK of biology faculty. Data included semi-structured interviews, classroom observations, documents, and instructional artifacts. A qualitative inquiry was designed to conduct an in-depth investigation focusing on the PCK of six instructors, particularly the types of knowledge they used for teaching biology. The findings of this study reveal that the PCK of the biology faculty included eight domains of knowledge: (1) content, (2) context, (3) learners and learning, (4) curriculum, (5) instructional strategies, (6) representations of biology, (7) assessment, and (8) building rapport with students. Three categories of faculty PCK emerged: (1) PCK as an expert explainer, (2) PCK as an instructional architect, and (3) a transitional PCK, which fell between the two prior categories. This research serves to inform faculty and administrators building programs to improve undergraduate science education.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Relevance and Self-Efficacy in STEM Learning
10:15am - 11:45am, Randolph
Presider: Dorene R. Medlin, Albany State University

How do STEM Students Find Relevance in their Learning?

Yun-Hsin Chen, Olin College of Engineering
Margaret Lidrbauch, Olin College of Engineering
Robert Siegel, Olin College of Engineering
Yevgeniya V. Zastavker, Olin College of Engineering
Jonathan Stolk, Olin College of Engineering
Alexander Dillon, Olin College of Engineering
Michael Gross, Wake Forest University

ABSTRACT:
Educational research presents a compelling case that motivation - the psychological drive to take action – is tightly connected to outcomes such as development of positive self-efficacy, critical thinking, creativity, self-regulation, and pro-social behavior. Research shows that motivational orientation and resulting behaviors in the classroom are influenced by student's perceptions of relevance. This paper explores the ways in which STEM students describe relevance in their week-to-week learning activities. We investigate two research questions: (1) How do students find what they are doing in the course to be personally relevant to them? and (2) In what ways do students' conceptions of relevance vary across different STEM courses and institutional settings? We present a relevance construct as a building block for a preliminary emergent framework describing different types of relevance.

Describing Undergraduate STEM Teaching Practices: A Comparison of Instructor Self-Report Instruments

Cody T. Williams, Western Michigan University
Emily M. Walter, Western Michigan University
Charles R. Henderson, Western Michigan University
Andrea L. Beach, Western Michigan University

ABSTRACT:
Improving undergraduate science instruction is an agreed upon goal among science educators and researchers. Collecting data on current instructional practices is the first step in enacting meaningful change. Self-report survey instruments are one of the most common tools used for collecting data on instructional practices. This paper examines faculty self-report instruments included in a recent AAAS report. The analysis includes comparisons between the instruments at both the instrument and item level. The instruments were qualitatively analyzed to determine the nature of the instruments. Items were quantitatively sorted into instructional practice codes based on content. The paper provides a deeper understanding of currently available instruments and identifies gaps these instruments. In addition, suggestions for future instrument development are included.

Validation of Students' Assessment of Their Learning Gains Instrument for Assessing Perceptions in Chemistry Classes

Venkat R. Vishnumolakala, Curtin University
David F. Treagust, Curtin University
Daniel Southam, Curtin University
Mauro Mocerino, Curtin University

ABSTRACT:
This research was aimed to validate the Students' Assessment of Their Learning Gains (SALG) – an instrument used for students to assess their perception of their learning in chemistry classes. While this instrument has been used in a number of studies in student learning of university level chemistry, its construct and convergent validity have not been previously determined. The research utilised a post-positivist, quasi-experimental mixed-method design. The data obtained from two cohorts of first year chemistry was explored employing exploratory and confirmatory factor analyses for establishing convergent validity, the factor loadings and internal consistency reliability measures. The exploratory factor analysis revealed a four factor structure meeting the

high reliability criteria. The fit-indices of the measurement model of the confirmatory factor analysis meet the criteria of model-fit indicating construct validity in terms of the consistency of the factor structure of SALG instrument. The internal consistency values are highly satisfactory. With the establishment of a four factor structure using EFA and CFA, the SALG instrument can be helpful to the researchers and chemistry educators in measuring students' perceptions of their learning.

Assessing Multinational Interest in STEM ? Triggers of Interest
Adam V. Maltese, Indiana University, School of Education
Heidi A. Ross, Indiana University, School of Education
Shenghai Dai, Indiana University, School of Education
ABSTRACT:
America's position at the forefront of research and innovation is a common talking point at the highest levels of government (e.g., Obama, 2011). At the same time, there is mounting interest in comparing students across state and national boundaries, particularly on measures of achievement. Concerns about the STEM workforce and attempts to understand and improve science education, writ large, are not singular to the US; they are shared by colleagues around the world. The main objective of this research is to develop surveys, collect and analyze data that provide an assessment of interest in STEM from university-level undergraduates, graduate students and faculty in the US and other countries among the leaders in areas related to STEM. The results presented here come from data collected during fall 2013 through spring 2014 at colleges and universities in China (n=1222 participants), the US (n=1505) and Australia (n=570). Generally, results indicate that classes at school are the most common experience reported across countries and times for triggering interest. . Books and magazines are commonly cited as one of the main sources of interest in China, are less common but oft mentioned in Australia, and are least commonly cited in the US.

Relationships between Mathematics Self-Efficacy and Abilities for First Year Engineering Students with Poor Mathematics Preparation
Gustavo Moran, Clemson University
Lisa C. Benson, Clemson University
ABSTRACT:
Solving complex mathematical problems is a required skill for students in engineering majors. Some students pursue engineering in spite of not having strong mathematical knowledge, skills and abilities. These students may feel stressed and discouraged if they experience difficulties in their first college mathematics courses, leading to attrition in engineering. This study analyzed the mathematics self-efficacy of engineering students with poor mathematics preparation. Interviews were conducted with two students at a southeastern university who received low scores on a mathematics placement test required for all incoming students. Data was analyzed using a grounded theory approach, with the goal of building an evidence-based theory about engineering students' mathematics self-efficacy and its relationship to their performance in college mathematics courses. Preliminary findings suggest that mathematics performance of students with high self-reported mathematics self-efficacy can differ depending on their actual mathematics knowledge, skills and abilities. The student who appeared to have a small gap between self-efficacy and abilities worked hard to overcome his deficiencies; the student who described overconfidence (higher self-efficacy relative to his actual abilities) procrastinated and put forth less effort when faced with difficulties. Students perceived their overall mathematics self-efficacy as being higher than their problem solving self-efficacy in mathematics.

Strand 6: Science Learning in Informal Contexts
Symposium - When the Informal Becomes Formal in the Higher Education Preparation of Science Teachers
10:15am - 11:45am, Grand B

Presiders:
David Silvernail, University of Southern Maine
Maritza Macdonald, American Museum of Natural History
Presenters:
David Silvernail, University of Southern Maine
Maritza Macdonald, American Museum of Natural History
Amy Johnson, University of Southern Maine
Julie Contino, American Museum of National History
Natasha Cooke-Nieves, American Museum of National History
Angela M. Kelly, Stony Brook University
Preeti Gupta, American Museum of Natural History
Harriet Fayne, Lehman College, CUNY
Maria Rivera, Barnard College
Jamie Wallace, American Museum of Natural History
Denton Ebel, American Museum of Natural History
ABSTRACT:
The symposium will explore the role of informal science education institutions (ISEs) in the role of science teacher preparation. Two different models for involvement will be described: collaborations with university-based preparation programs to provide supplementary informal science learning experiences for pre-service teachers in formal programs, and a pilot Master of Arts in Teaching (MAT) preparation program that is housed entirely within a museum. The rationale for involving ISEs in pre-service teaching programs will be established, and presenters will describe strategies for successful implementation of various components of each model based on their initial experiences. Now entering its third year of implementation, the MAT program also has preliminary findings of impacts from evaluation data collected from the first two cohorts of program graduates. Evaluation findings will be shared where applicable to indicate emerging effective practices and implications for replication of program elements at other ISEs.

Strand 7: Pre-service Science Teacher Education
Symposium - Defining and Understanding Scientific Practices Pre-Service Science Teacher Education
10:15am - 11:45am, Columbus CD
Discussant: Carla Zembal-Saul, Penn State University
Presider: Sibel Erduran, University of Limerick
Presenters:
Sibel Erduran, University of Limerick
Deniz Saribas, Istanbul Aydin University
Ebru Z. Mugaloglu, Bogazici University
Ebru Kaya, Bogazici University
Zoubeida R. Dagher, University of Delaware
Gaye Ceyhan, Bogazici University, Istanbul-Turkey
ABSTRACT:
The notion of "scientific practices" has infiltrated curriculum policy documents, such as Next Generation Science Standards in the United States and there is increasing demands on teachers to engage in the teaching of scientific practices. But what are scientific practices? How are scientific practices defined? How are they represented in the science curriculum policy? How can they be incorporated into teacher education programs? The proposed symposium will address these questions. Presentation 1 focuses on a theoretical overview of scientific practices, drawing on work in philosophy of science to illustrate a holistic representation that infuses various epistemic, cognitive and social features of science. Presentation 2 is conducted by teacher educators

who have incorporated scientific practices in their pre-service teacher education program. Their account is based on an auto-ethnographic methodology. Presentation 3 outlines an empirical study using quantitative methodology and investigating pre-service science teachers' perceptions of scientific practices. Presentation 4 takes on a qualitative approach illustrating pre-service science teachers' visual representations of scientific practices. Presentation 5 illustrates through case study methodology how pre-service teachers engage in scientific practices. Overall the symposium provides a comprehensive account of scientific practices using a diverse range of methodologies.

Strand 8: In-service Science Teacher Education
Innovative Approaches to Assessing and Supporting Science Teacher Knowledge, Beliefs, and Practice
10:15am - 11:45am, Grand Suite 3
Presider: Eilish McLoughlin, Dublin City University

Conceptual Storylines: Examining Teachers' Criteria for Evaluating Lessons
Deborah L. Hanuscin, University of Missouri
Eun Ju Lee, University of Missouri
Kelsey Gillstrom, University of Missouri
Annie Arnone, University of Missouri
Zandra de Araujo, University of Missouri
ABSTRACT:
A conceptual storyline, also referred to as a 'science content storyline' (Roth et al., 2011), involves the sequencing and linking of learning activities and ideas in ways that are instructionally meaningful to student learning. In this exploratory study, part of a much larger research program, we developed a Conceptual Storyline Probe (CSP) to examine teachers' ability to recognize a coherent conceptual storyline. The CSP pairs descriptions of two lessons that are related to the same topic, both of which include activities that aligned with the purposes and intent of each phase of the 5E Learning Cycle. The lessons parallel each other in their design with the exception being the conceptual storyline (one is coherent and one is not). We administered the CSP to 33 elementary teachers and 5 preservice teachers during a summer professional development institute. Of the 38 participants, 26 (68.4%) selected the lesson with the coherent storyline (Lesson 1) as their preference. Yet, of the 130 features teachers attended to, more than half (56.2%) of these were related to students. Few teachers attended to aspects of the coherence of the conceptual storyline to evaluate the quality of the lessons.

Development of a Coding System and Instruments for Assessing the Quality of Instructional Behaviors
Peng He, Northeast Normal University (China)
Changlong Zheng, Northeast Normal University (China)
Xiufeng Liu, State University Of New York At Buffalo (SUNY)
ABSTRACT:
The main purpose of this study is to develop a valid and reliable instrument for measuring the quality of instructional behaviors in an entire chemistry lesson in Chinese mainland. Specifically, a new coding system was created to identify all instructional behaviors under the theory of Classroom Teaching and Learning System (CTLS). Six instruments were developed to assess six specific Common Instructional Behaviors Chains (CIBCs). 2790 CIBC from 93 chemistry lessons were evaluated to validate these instruments. Data analysis indicated that these instruments exhibited satisfactory validity and reliability with Chinese chemistry lesson used. The Cronbach's alpha coefficients were higher than 0.90 for these instruments, indicating a satisfactory level of internal consistency. The analysis also showed that there exists significant difference in the quality of instructional behaviors between well-design lessons and ordinary lessons. The theoretical underpinning of these instruments combined with the statistical data indicates that these instruments possess good construct validity

and that they are proved to be promising instruments that can be utilized for research purpose, and as a teacher training and coaching means within the field of science education.

Effects of Fidelity of Implementation on Elementary Science Teachers' Implementation of Engineering Practices

Brenda M. Capobianco, Purdue University
Jacqueline DeLisi, Education Development Center, Inc

ABSTRACT:
This study explores fidelity of implementation (FOI) as it applies to teachers' integration of engineering practices in the elementary science classroom. The importance of examining FOI in science education in the U.S. lies within the realm of teachers meeting the demands of the NGSS, specifically, engineering practices. As individual states begin to adopt the new science standards, there is greater need for understanding how to support teachers in implementing engineering practices. Equally important is the growing interest among intervention researchers in determining how well these practices are implemented according to the program and how best to address FOI. The study was conducted within a large, multi-year partnership designed to assist elementary science teachers with improving students' science learning through engineering design. As the criterion for measuring FOI, we focused on adherence, duration, and quality of delivery across two variables of science (i.e., scientific understanding and scientific practices) and two variables of engineering (i.e., engineering conceptual understanding and engineering practices). Results indicated that two of the measures of FOI using classroom observations and interviews had significant effects of teachers' implementations. Results are discussed in terms of issues about measurement of FOI in the context of new science education reform.

Using Conjecture Mapping in Formative Assessment: Supporting ELL Teachers' Teaching Argumentation Practices in Science Classrooms

Suna Ryu, University of California, Los Angeles
William A. Sandoval, Univeristy of California, Los Angeles

ABSTRACT:
The aim of this study was to examine how conjecture mapping can aid teachers with understanding and appropriating the theoretical and pedagogical background of scientific argumentation when using formative assessment, and to examine how they position themselves in an active role, rather than simply delivering a formative assessment. When using this assessment, understanding the research basis and theoretical background is particularly important for teachers because this understanding enables them to provide appropriate feedback. Conjecture mapping is a technique used in design research to map the links between theoretical ideas and outcomes. It shows how theoretically salient features of design work to produce results that are desired and predicted. A three-month long, qualitative case study design was used. We collected and analyzed video recordings of teachers enacting formative assessment, verbal and e-mail interviews with teachers, and teacher-generated conjecture maps. Helping teachers to be able to develop, reflect, and revise their teaching practice by themselves is necessitated as argumentation needs sustained, on-going support from teachers. We found that conjecture mapping may aid teachers in improving their understandings of the link between theoretical ideas and enacted formative assessment, which will enable them to improve their reflections and feedback on student argumentation.

Strand 8: In-service Science Teacher Education

Related Paper Set - Findings from Federally Funded STEM Professional Development Programs: Effective Practices for the Next Generation

10:15am - 11:45am, Gold Coast

ABSTRACT:

The Next Generation Science Standards guided by A Framework for K-12 Science Education emphasize the need for preparing scientifically literate citizens that are capable of making informed decisions in an increasingly complex world. Teachers are challenged with finding ways to help students make connections between science, math, technology, engineering, and literacy (i.e., an emphasis on Grades 6-12 Common Core Literacy for Science and Technical subjects). The research described in this paper set focuses on professional development with K-12 STEM teachers and specifically how participants' math/science content and pedagogical knowledge were impacted. This paper set describes four projects funded by the Tennessee Higher Education Commission and a university in Tennessee, three projects were part of the Race to the Top initiative (Fall 2012-Fall 2013) and one project was part of the Improving Teacher Quality (ITQ) initiative (Fall 2013-Fall 2014). All projects involved high-need rural school systems from middle and east Tennessee. Training sessions, conducted by education, math, science, and engineering faculty, served to effectively model teaching techniques and focused on building science and math pedagogical content knowledge.

STEM Around US
Sally Pardue, Tennessee Technological University
Martha Howard, Tennessee Technological University

For Your Informational Text: Exploring, Evaluating, and Writing with Common Core Collaborations Starring Librarians and Teachers
Julie Stepp, Tennessee Technological University

From Earth to Space with STEM: Professional Development for Grades 4-7 Math and Science Teachers
Leslie A. Suters, Tennessee Technological University

Shaping Early STEM Learning in Grades K-2
Jane E. Baker, Tennessee Tech University

Strand 9: Reflective Practice
Symposium - When Chemistry Education Researchers Met a New Paradigm: A Graduate Seminar Reflects on Embodied Cognition
10:15am - 11:45am, Columbus KL
Presiders:
Dor Abrahamson, Graduate School of Education, University of California, Berkeley
Sharona T. Levy, University of Haifa
Discussant: Joseph Krajcik, Michigan State University
Presenters:
Elon Langbeheim, Arizona State University
Ran Peleg, University of Haifa
Asnat Zohar, University of Haifa
ABSTRACT:
What might it take for researchers to adopt a new paradigm? 10 graduate students, post-doctoral fellows, and members of faculty engaged in a year-long reading seminar on embodiment theory. Participants differed in their familiarity with embodiment literature, ranging from novices to those who actively engage in its research. In this collective reflection symposium, course participants offer testimonials, in which they each describe their ongoing research project, the idea from the readings that they attempted to integrate into their project, and their struggles and successes in doing so. We analyzed these testimonials along multiple emergent categories to

formulate principles for effective facilitation of graduate-level reading courses. This generative case study could help lecturers look beyond course evaluations at course process.

Strand 10: Curriculum, Evaluation, and Assessment
Related Paper Set - Rigorous Approaches to Assess Science and Engineering Learning
10:15am - 11:45am, Roosevelt
Presiders:
K. Anna Douglas, Purdue University
Senay Purzer, Purdue University

ABSTRACT:
There is not one type of assessment instrument that will suffice to answer all science and engineering education research questions; rather the type of instrument should match the purpose of the assessment and have strong evidence of validity. This paper set brings together four studies that focus on rigorous modern assessment methods which enable collection of differing sources of evidence as to what students know and can do in regard to complex science and engineering learning. The first paper examines whether a test to measure undergraduate students' information literacy fairly assesses students from diverse backgrounds through applications of a Rasch model. The second paper examines whether an assessment to measure undergraduate students' awareness and motivation to pursue nanotechnology education and opportunities functions according to the theoretical framework. The third paper explores the use of computer aided design to gather evidence about students' learning progression through the course of a unit, based on improved efficiency in their design projects. The fourth paper utilizes think aloud interviews along with a multiple-choice assessment, to gather evidence of students' understanding of engineering concepts. We recommend sources of validity that can be examined for differing types of assessment instruments to inform proper use and inferences.

The Development of NanoSurvey through Argument Based Validity
Oguz Hanoglu
K. Anna Douglas, Purdue University
Heidi Diefes-Dux, Purdue University
Krishna Madhavan

Use of Rasch Measurement to Examine Fair Assessment of Information Literacy
K. Anna Douglas, Purdue University
Vivian G Alexander
Senay Purzer, Purdue University
Michael Fosmire

Developing an Engineering Design Assessment Using Think-Aloud Interviews Subject/Problem
Meltem Alemdar, Georgia Institute of Technology
Jeremy Lingle, Georgia Institute of Technology
Roxanne A. Moore, Georgia Institute of Technology
Stefanie A. Wind, Georgia Institute of Technology

Performance Assessment of Engineering Design Using Process Analytics Based on CAD Software
Charles Xie, Concord Consortium
Saeid Nourian
Shiyan Jiang

Rigorous Approaches to Assess Science and Engineering Learning
Senay Purzer, Purdue University
K. Anna Douglas, Purdue University

Strand 11: Cultural, Social, and Gender Issues
Symposium - Identity Research and its Relation to Becoming Next Generation Science Learners and Educators
10:15am - 11:45am, Wrigley
Discussant: Justine Kane, Wayne State University
Presenters:
Gillian U. Bayne, Lehman College of the City University of New York
Heidi B. Carlone, The University of North Carolina at Greensboro
Felicia Moore Mensah, Columbia University
Stacy Olitsky, Saint Joseph's University
Tara O'Neill, University of Hawaii at Mānoa
Joseph L. Polman, University of Colorado Boulder
Jrène Rahm, Université de Montréal, Canada
Gale Seiler, Iowa State University
Beth Warren, Chèche Konnen Center at TERC
Aerin Benavides, The University of North Carolina at Greensboro
Tess Hegedus, The University of North Carolina at Greensboro
Lacey Huffling, The University of North Carolina at Greensboro
Catherine Matthews, The University of North Carolina at Greensboro
Terry Tomasek, Elon University
Elizabeth Menig, University of Illinois at Chicago
Maria Varelas, University of Illinois at Chicago
Danny B. Martin, University of Illinois at Chicago
Marcie Gutierrez, Chicago Public Schools
Edna Tan, University of North Carolina at Greensboro
Angela Calabrese Barton, Michigan State University
Cynthia Graville, Saint Louis University
Engida Gebre, University of Colorado Boulder
Audrey Lachaîne, Université de Montréal, Canada
Viviane Boucher, Université du Quebec à Montréal (UQAM)
Ann S. Rosebery, Chèche Konnen Center at TERC
Eli Tucker-Raymond, Chèche Konnen Center at TERC
Joan Brunetta, Chèche Konnen Center at TERC

ABSTRACT:
The proposed symposium brings together science education scholars who attend to issues of identity construction, especially as it relates to equity and justice, in relation to people who are historically marginalized in society, schooling, and science. The authors contribute to the ongoing conversation around science identity construction of children, youth, and teachers in various settings—formal and informal, in and out of schools/classrooms—in order to explore the ways in which science identity is related to the teaching and learning of science in the context of the new Framework for K-12 Science Education and the resulting NGSS. The various studies presented in this symposium will explore the Framework's call to promote scientific literacy by fostering the development of science identities and building on the interests and strengths of culturally and linguistically diverse students and other aspects of equity and justice in relation to science

education and identity construction. Each presenter will prepare a poster version of her or his paper. The symposium will consist of four parts: introduction of papers, dialoging with presenters, synthesizing commentary, and whole-group discussion, which will be facilitated by the discussant.

Strand 12: Educational Technology
Scaffolding Strategies and Frameworks
10:15am - 11:45am, Columbus IJ
Presider: Josephine Desouza, Ball State University

Technology Scaffolds of Teamwork Coordination in Collaborative Problem Solving
Pavlo D. Antonenko, University of Florida
Kent J. Crippen, University of Florida
Lauren Eutsler, University of Florida
ABSTRACT:
This paper reports the results of a study that was designed to examine the usability of a computer-supported collaborative learning environment entitled ECLIPSE: Environment for Collaborative Learning Integrating Problem Solving Experiences. ECLIPSE provides cognitive, metacognitive, process and social interaction scaffolds for teams of students that define and solve problems in this learning environment. In this report we focus primarily on discussing the most salient finding of our study: the importance of providing both task-specific social interaction scaffolds and global, system-wide teamwork coordination tools to support task division, role distribution, time management, and technical coordination of the collaborative problem-solving process. Further research needs to be conducted to determine the optimal ratio of task-specific versus system-wide interaction scaffolds, and effective configurations of affordances of such tools to support motivational, affective, cognitive, and metacognitive aspects of computer-supported collaborative learning.

Comparing Linear vs. Hypermedia Online Learning Environments to Bridge Curricular Requirements and Students' Questions
Ayelet Baram-Tsabari, Technion - Israel Institute of Technology
Hani Swirski, Technion - Israel Institute of Technology
ABSTRACT:
While interest is central to learning, considerable disparities have been reported between students’ science interests and the science curriculum. This study explored how 5th grade students' (n = 72) competence, relatedness and interest levels changed as a consequence of using two online learning environments, which bridged the students' anonymous curiosity questions and the required science curriculum on the topic of "Natural Resources". One environment provided answers to the students’ questions (a ‘linear’ environment), whereas the other provided relevant links and sent the students to find the answer by themselves (a ‘hypermedia’ environment). Each student experienced each of the environments, and their competence, relatedness and interest levels were examined using a closed pre/posttest questionnaire. Interest level increased only after experiencing learning with the linear environment, whereas competence level increased only after using the hypermedia environment. These findings point to the potential of using online learning environments to narrow the gap between the curriculum and students' interests, while emphasizing the pedagogical need for diverse online environments for different learners and learning goals.

Supporting Argumentation Practices with Knowledge Organization via Student-generated Multiple External Representations
Bahadir Namdar, Recep Tayyip Erdogan University
Ji Shen, University of Miami

ABSTRACT:
Recent science education policy documents promote engaging students in practices similar to that of scientists. However, even though scientists use MER as advanced knowledge organizers to communicate their arguments; still little is known about how students organize their knowledge with MER to support argumentation in science education settings. Therefore, in this research we investigate the interplay between learners' knowledge organization and argumentation practices when they were given a web-based knowledge organization platform.

Scaffolding Argumentation in Science Classrooms
Tugba Keser, Trakya University
ABSTRACT:
The purpose of this case study was to investigate what scaffolding conditions help students improve the quality of their arguments in science classrooms. For this purpose, four focus groups from four 11th grade classrooms were selected as volunteer participants in two Western Massachusetts High Schools. They discussed a central question with three alternative theoretical accounts of the relationship between the pressures of Helium and air balloons in space when they constructed and defended their arguments using the “Gas Properties” computer simulation in pair and classroom discussions. The results depicted that the central question, teachers’ questions, peers’ questions, self-questions, representation of investigations, similar or counter arguments promote and challenge students to articulate and elaborate their arguments when students construct and defend their arguments. Different from in pair discussions, in classroom discussions focus group students tried to win their opponents over to their points of view and to weaken opposing views with making their evidence visible on the simulation, which led students to produce the highest quality of arguments.

Strand 14: Environmental Education
Climate Change
10:15am - 11:45am, Grand D North
Presider: Jennifer H. Forrester, University Of Wyoming

An Investigation of Science Educators' Views of Role and Responsibility for Climate Change Education
J. Randy McGinnis, University of Maryland
Robert C. McDonald, University of Maryland
Emily Hestness, University of Maryland
Wayne Breslyn, Montgomery County Public Schools
ABSTRACT:
This exploratory study examined the views of science educators concerning roles and responsibility (personal and others’) for teaching climate change education. Specifically, we focused on the views of a diverse group of science educators (K-12 science educators-formal and informal, and higher education science educators, content and pedagogy experts) from two Mid-Atlantic States in the USA who participated in a one-week residential professional development summer Academy on climate change education. We present findings based on the research question: What do science educators from differing subgroups in a community (K-12, formal and informal educators, and higher education, science content and pedagogy experts) believe are the roles and responsibilities for climate change education (personal and other’s) concerning climate change education? We found that participants in their own group thought similarly about climate change but differed in notable ways in how they viewed the ‘others’’ (those not in their subgroup) responsibilities for promoting understanding of climate change. As a result, we found that there exists a possible mismatch in views based on group membership. A key implication concerns the design and implementation of effective professional development in climate change education, specifically, and other science topics, generally, that include participants from differing groups of educators.

Pre-service Teachers' Understanding of the Atmosphere Related Environmental Problems

Harika Ozge Arslan, Yuzuncu Yil University
Ceyhan Cigdemoglu, Atilim University

ABSTRACT:
This study aims to investigate understanding of pre-service teachers' on environmental problems regarding the global warming, greenhouse effect, ozone layer depletion, and acid rains and reveal their misconceptions on these concepts. "The atmosphere-related environmental problems diagnostic test: AREPDiT" as administered to 118 pre-service teachers to assess their understanding about the nature, causes, consequences, and the cures of these problems. There were 13 three-tier items on the AREPDiT; the first tiers were multiple-choice content question, the second tiers contain possible reasons for the responses given in the first tiers, and the third tiers were confidence tiers. This structure of the AREPDiT enables researchers to categorize the incorrect responses as lack of knowledge, lucky guess, and/or misconceptions rather than merely labeling them as misconceptions. The results reveal that majority of the respondents demonstrated limited understandings and held seven common misconceptions similar with high school students. They had confusion between global warming and ozone layer depletion, many of them thought that holes in the ozone layer were responsible for global warming and thus global warming would result in an increase in incidence of skin cancer. Further studies may design lessons to remediate pre-service teachers' misconceptions and get them to be more environmentally aware teachers.

Scientific Reasoning about Global Climate Change: A Grounded Theory Study

Shiyu Liu, The Pennsylvania State University
Frances Lawrenz, University of Minnesota

ABSTRACT:
This grounded theory study aimed to develop a comprehensive model that captures the cognitive processes involved in reasoning about climate issues and potential variables that may affect such reasoning. Twenty-six undergraduate students participated in this study. Our findings revealed that participants were mostly drawn to the surface features of evidence on global climate change (GCC) rather than its scientific meanings and values. When faced with competing perspectives, they predominantly favored arguments that supported their own beliefs with little or weak scientific reasoning about the opposing arguments. Moreover, while prior knowledge was not a direct indicator of performance in evidence evaluation, participants who held more knowledge about GCC were more engaged in complex reasoning. Many factors, including participants' epistemological understandings, prior knowledge, personal beliefs, and reading capacity, were found to have bearings on the way they reasoned. In all, this study constituted our first steps in bridging cognitive research with science and environmental education. It contributed to the ongoing debates in climate change education about how to enhance climate literacy. From a holistic perspective, this work lays a foundation for future endeavors in curriculum design as environmental educators attempt to facilitate scientific reasoning in climate change education.

Is Anyone Learning About Climate Change? The extent of Climate Change in Science Standards

Barry Golden, University of Tennessee

ABSTRACT:
This study analyzed the existence of climate change in extant science frameworks in the United States. The science standards/and/or frameworks of 50 states plus the NGSS standards (Achieve, Inc., 2013) were analyzed to gauge the emphasis given to global warming/global climate change (GW/GCC). The analysis was done via a word search for key items related to "global warming", "climate change", and the "greenhouse effect". The documents were then coded, on a scale from zero to four, based upon how extensive and detailed their framework dealt with GW/GCC. For instance, a framework with standards indicating the importance of

understanding GW/GCC, as well as an emphasis on understanding the likely anthropogenic contributions (which would make them consistent with the current climatological consensus), scored a “4”, while one in which the key concepts did not appear earned a “0”. Findings indicated a wide range of variation in how states addressed the issue. Eighteen states earned the lowest possible score, while only five states scored a four. The authors use the frameworks data to conclude that few American K-12 students are likely to learn about GCC.

Concurrent Session #12
1:00pm – 2:30pm

Strand 1: Science Learning, Understanding and Conceptual Change
Related Paper Set - Related Poster Session: Learning Pathways to Environmental Science Literacy
1:00pm - 2:30pm, Wrigley
Presider: Beth A. Covitt, University of Montana
Discussant: Christina Schwarz, Michigan State University
ABSTRACT:
In this thematic poster session we share results from a decade of work aimed at developing and validating environmental science literacy learning progressions (LPs) at middle and high school levels, and subsequently employing those LPs to support learning necessary for informed citizen decision-making about socioecological issues. Our research addresses three disciplinary strands (i.e., biodiversity, carbon cycling, and water cycling) as well as transcending themes like quantitative reasoning. Our scope encompasses facets of NGSS including core disciplinary ideas (e.g., Earth’s Systems, Ecosystems, and Biological Evolution), scientific practices, and crosscutting concepts (notably systems and system models, structure and function, energy and matter, and scale). A core result is a unifying framework that describes a span from informal/force-dynamic toward scientific-model based discourse concerning environmental systems. In this session, we discuss how discourse-based LP frameworks may be used to understand student learning in terms of growth toward environmental science literacy. Addressed questions include 1) How do our discourse-based LPs frame learning? 2) How can we measure student learning with LPs and how does LP-based instruction lead to learning? And 3) to what extent and in what ways can our LP work be extended to address new topics and lines of scholarly inquiry?

Defining Common Elements of Environmental Science Literacy Learning
John C. Moore, Colorado State University
Charles W. Anderson, Michigan State University
Alan R. Berkowitz, Cary Institute of Ecosystem Studies
Beth A. Covitt, University of Montana
Kristin L. Gunckel, University of Arizona
Laurel Hartley, University of Colorado Denver
Jennifer H. Doherty, University of Washington
Hui Jin, Ohio State University
Michele Johnson, University of California, Santa Barbara
Christina V. Schwarz, Michigan State University

A Learning Progression-Based Biodiversity Teaching Unit: Investigating the impact of Teacher Knowledge and Implementation Fidelity on Student Learning
Laurel Hartley, University of Colorado Denver
Jennifer H. Doherty, University of Washington
Cornelia Harris, Cary Institute Of Ecosystem Studies
John C. Moore, Colorado State University

Alan R. Berkowitz, Cary Institute of Ecosystem Studies
Charles W. Anderson, Michigan State University

Learning about Water Flow as a Result of Learning Progression-Based Instruction
Beth A. Covitt, University of Montana
Kristin L. Gunckel, University of Arizona
Ivan Salinas, University of Arizona

Student Learning of Local Tree Diversity and the Concept of Common Ancestry
Yael Wyner, City College of New York
Jennifer H. Doherty, University of Washington

Environmental Science Literacy: The Role of Quantitative Reasoning
Robert Mayes

How Do Students Construct Explanations at Different Levels of an LP?
Nissa Yestness

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Socio-scientific Dimensions and Science Learning
1:00pm - 2:30pm, Roosevelt
Presider: David Stroupe, Michigan State University

Science Literacy as an Approach to Engaging Young People in Improving their Health Behaviours
Andri Christodoulou, University of Southampton
Kathryn S. Woods-Townsend, University of Southampton
Keith M. Godfrey, University of Southampton
Marcus M. Grace, University of Southampton
Janice B. Griffiths, University of Southampton
Mark A. Hanson, University of Southampton
Hazel M. Inskip, University of Southampton
ABSTRACT:
This proposal aims to discuss the importance of promoting healthy behaviours during K-12 education and puts forward the argument that an effective and sustainable way to promote health literacy is through science education. Using socio-scientific issues as a framework for teaching about healthy behaviours at the secondary school level, we argue that health literacy, and science literacy are inherently related and should be presented as such within K-12 education. Health literacy emphasises educating individuals about their health and enabling them to develop the critical and evaluative thinking skills that are required to make informed health-related decisions and develop healthy behaviours. Such critical and evaluative thinking skills and the ability to consider and weigh evidence are core practices of the scientific community, and one of the advantages that science education has to offer to the general education of young individuals. Using non-communicable diseases as the context, we propose an educational intervention that can promote both scientific and health literacy whilst engaging students in scientific practices.

Eliciting Students' Understanding of River Geography and Socioscientific Issues through a Critical Response Protocol
Senenge T. T. Andzenge, University of Minnesota

Engin Karahan, University of Minnesota
Devarati Bhattacharya, University of Minnesota
Gillian Roehrig, University of Minnesota

ABSTRACT:
This qualitative study presents an analysis of secondary school students' perception of river landscapes to address the fundamental dissonance between scientific understanding and public perceptions of a river-based issue. In this study, we elicited student understanding about the apparent difference in turbidity between two local rivers. Additionally, we observed students using the term "dirty" interchangeably with "pollutants" and "pollution" which also raised questions about the students' notion of sedimentation and the river landscape as a whole. Implications of this work will be useful for watershed managers and formal and informal science educators.

Reflective Judgment and Argumentation Skills of Preservice Teachers in a Socioscientific Issues-Based Laboratory Inquiry Course

Dilek Karisan, Yuzuncu Yil University
Ozgul Yilmaz-Tuzun, Middle East Technical University
Dana L. Zeidler, University of South Florida

ABSTRACT:
Socioscientific issues (SSI) are commonly used to engage students with science related issues that allows them to integrate science in daily life issues. The purpose of this study is to explore whether SSI embedded in an inquiry-based laboratory course may reveal nuanced aspects of the argumentation and reflective judgment patterns of preservice teachers. A design-based research approach was selected for the present study. Four SSI were covered throughout the course with each issue lasting two weeks (discussion weeks and experiment weeks). The participants were an intact group of 20 pre-service teachers. Data were collected (and triangulated) by using interviews, written laboratory documents and video transcriptions of classroom discussions throughout the spring semester. To establish inter-rater reliability of the data analysis, transcriptions and laboratory reports were coded by three researchers independently. The rate of agreement on the coding results between three researchers was greater than 90%. Results of the study revealed that PTs' reflective judgment scores tended to increase over the course of the semester from first experiment to last experiment and PTs use of evidence-based argumentation skills in the resolution and negotiation of SSI were dominated by fairly high-level argumentation scores.

Attitudes and Language Use in Group Discussions on Socio-scientific Issues

Mats G. Lindahl, Linnaeus University
Anne-Mari Folkesson, Linnaeus University

ABSTRACT:
The use of Socio-scientific Issues (SSI) in science education aiming at fostering critical thinking and decision-making capacities is known to develop the quality of students' socio-scientific arguments. Teachers scaffolding has been shown to be important for the quality of students' reasoning. Although students' untutored socio-scientific discussions are recognized as important for reasoning quality, little is known about these interactions among peers. Such information is crucial for further development of teachers' scaffolding. The aim of this study is to explore the underpinnings of student discussions on SSI in order to develop understanding for key aspects with importance for the faith of students' decision-making conversation. Data were transcribed discussions from 4 groups of Swedish high-school students discussing "Wolves in Sweden and biodiversity". Our theoretical framework builds on Dewey's notion of Open-mindedness and Bernstein's communication codes. Students' inputs interrupting or re-vitalizing conversations were coded as Open-minded/Close-minded (OM/CM) and Elaborated/Restricted code (Ec/Rc) and their functions interpreted. In some utterances (Morals and Agitational talk) the use of Ec were found to interrupt or narrow the conversation. CM utterances (Morals and Opinions)

typically interrupted conversation, something that has to be counteracted by teachers by encouraging students' Open-mindedness in order to promote a multifaceted informal socio-scientific discussion.

Talking Climate Science - How Teachers Frame Climate Change in the Classroom & Why It Matters
Kirstin C. Busch, Stanford University
ABSTRACT:
The Next Generation Science Standards include climate change, ensuring the topic will be covered in U.S. science classrooms in the near future. The larger question, though, is how can the teaching of climate change be done in such a way as to ascribe agency, defined here as a willingness to act, to students? Framing – as both a theory and an analytic method – has been used to understand how language in the media can affect the audience's intention to act. Teachers are acting as the frame builders within the classroom, and this study examines teachers' frames through their choice of language while teaching about climate change. Implications are drawn by linking the frames teachers used to research on the effective communication of climate change.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Symposium - A Research-Practice Partnership towards Agentive Science Learning: Advancing Elementary Students' Science Learning and Practice-Linked Identities
1:00pm - 2:30pm, Columbus CD
Discussant: Leah Bricker, University of Michigan
Presenters:
Kari Shutt, University of Washington
Andrew Morozov, University of Washington
Phonraphee Thummaphan, University of Washington
Robert Abbott, University of Washington
Giovanna Scalone, University of Washington
Amy Winstanley, Bellevue School District
Nancy Vye, University of Washington
Leslie Herrenkohl, University of Washington
Angie DiLoreto, Bellevue School District
Leah A. Bricker, University of Michigan
ABSTRACT:
Activities in kit-based science units often lack some of the key qualities of authentic scientific practice as envisioned in the Next Generation Science Standards (NGSS). This related paper session focuses on underlying theory and outcomes from a 5-year R&D initiative on "agentive" science learning employing a model of design-based implementation research (DBIR). Findings from a yearlong, mixed-method comparative study involving 17 fifth grade classrooms are presented, including an overview of the underlying theory and pedagogical approach; analysis of the impact of the redesigned curriculum on student learning outcomes; discussion of agency and the development of students' practice-linked science identities; account of novice and experienced teachers' perspectives on teaching for agency; and the affordances and tensions of collaborative, iterative design work and lessons learned on sustaining long-term research-practice partnerships. The NGSS embrace a vision for science that positions students as participants of science. This session will contribute to our understanding of pedagogical models, design processes and institutional partnerships that advance this vision and promote student learning and identification with science.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Symposium - Designing Programs that Engage, Motivate, and Interest Youth to Pursue STEM Careers: NSF-Funded ITEST Projects
1:00pm - 2:30pm, Columbus IJ
Presider: Amie Patchen, Boston College
Discussant: Sarita Pillai, Education Development Center, Inc
Presenters:
Javed Khan, Tuskegee University
Marcia Rossi, Alabama State University
Fan Wu, Tuskegee University
Ruth Kermish-Allen, Island Institute
Karen Peterman
Suzanne MacDonald, Island Institute
Jacqueline DeLisi, Education Development Center, Inc
Mike Barnett, Boston College
Sarita Pillai, Education Development Center, Inc
Amie Patchen, Boston College
ABSTRACT:
In recent years there has been an increasing emphasis placed on preparing the next generation to be scientifically literate citizens proficient in the skills required to work in Science, Technology, Engineering, and Mathematics (STEM) career fields. The National Science Foundation's ITEST (Innovative Technology Experiences for Students and Teachers) program was developed in 2003, originally in response to concerns and projections about the growing demand for IT workers and STEM professionals. Presently, the ITEST program seeks to build understandings of best practice factors, contexts and processes contributing to K-12 students' motivation and participation in STEM and other STEM cognate domains. This symposium will present work done to engage, motivate, and interest youth in STEM across ITEST-funded projects. The symposium will include an overview of ITEST and its impact followed by three research focused sections. The three projects cut across cognitive and non-cognitive domains. They aim to examine how local contexts and innovative technologies can be leveraged to engage youth who would not normally be interested in STEM, and discuss how to measure the increasingly recognized important non-cognitive attribute of resilience in STEM.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Physics
1:00pm - 2:30pm, Grand B
Presider: Shane Bergin, School of Physics

Content Knowledge of Future Physics Teachers
Florian Gigl, University Duisburg-Essen
Simon Zander, University Duisburg-Essen
Andreas Borowski, University of Potsdam
Hans Ernst Fischer, University Duisburg-Essen
ABSTRACT:
In order to suggest improvements in content knowledge education of future physics teachers, it is important to first learn about present status and to develop an applicable model of content knowledge of physics teachers. To serve that purpose, we conducted a longitudinal study, testing students at German universities at two points of their studies. With increasing duration of the study, we managed to manifest our model of content knowledge, dividing the dimension into three sub-dimensions: school knowledge, deepened school knowledge and

academic knowledge. Comparing the content knowledge of physics student teachers with physics students, we could see different levels of their knowledge but similar learning gains.

The Change Process in a College Physics Faculty's Conceptions and Practices on Teaching for Conceptual Change

William A. Stoll, Georgia State University
Abdulkadir Demir, Georgia State University
Bulent Cavas, Dokuz Eylul University
Pinar Huyuguzel Cavas, Ege University

ABSTRACT:
The change process in a college physics faculty's conceptions and practices on teaching for conceptual change following an extended collaboration with a science education faculty is examined. Centered on a collaboratively taught physics class for secondary science teacher candidates, integrating physics content with a conceptual change pedagogical approach, a phenomenographic study of the physics faculty is presented. Based on interviews and observations, the physics faculty exhibits an increasingly sophisticated conception of teaching for conceptual change. In practice, the physics faculty displays a greater emphasis on viewing specific pedagogy through a conceptual change framework and explicitly connecting physics content with the conceptual change process involved in the students' learning of the concepts. A major factor appears to be the physics faculty experiencing firsthand the science educator's modeling. Further, the construct of the course, requiring the integration of physics content with explicit conceptual change pedagogy, challenges the physics faculty member to struggle and reflect on his own learning and practice of teaching for conceptual change. A limitation found was, despite a growing understanding, the physics faculty struggled to consistently model teaching for conceptual change and showed limited carryover to more traditional physics courses.

The Persistence of Men and Women in Upper Level Physics using Survival Analysis

Idaykis Rodriguez, Florida International University
Geoff Potvin, Florida International University
Laird Kramer, Florida International University

ABSTRACT:
Active-learning approaches to teaching introductory physics have been found to improve student performance and learning gains. We report on longitudinal investigations of student performance in upper level physics courses after having previously taken Modeling Instruction introductory physics courses at Florida International University. Student performance data were analyzed for academic years 2005-2014 in upper level courses including Modern Physics, Mechanics, Electromagnetism, and Quantum Mechanics. Using a statistical survival analysis methodology, we compare how students who took traditional or reformed Modeling Instruction introductory courses perform in these subsequent courses. We look for differential effects between men and women who had these two types of introductory experiences. We find that women overall survive upper level physics courses at a higher rate than men and all the women in the data also survive the entire physics program to completion while the men have a 95% survival rate in program completion. We also find that women who had Modeling Instruction have a lower survival rate in upper level courses than regular lecture taught women. The implications of this work for our understanding of the impacts of active-learning experiences will be discussed.

Student Behaviors and Discourse within an On-Line Group Homework Forum in an Introductory Physics Class

James F. Kisiel, California State University, Long Beach
Brandon Kawata, California State University, Long Beach

ABSTRACT:

In this study, student discussions from a newly developed interactive group-homework tool (Social Homework) were examined to gain a better idea of how physics students engaged with the tool as well as their peers. The tool, created with functionality similar to Facebook, was designed to provide small groups of students within a large lecture-based class, an opportunity for more active participation in their science learning. Initial analysis of the 'most-liked' conversations revealed that while a majority of the discourse was indeed physics related, most talk was at a surface or procedural level (e.g. here's the formula we should use) Further analysis revealed that much of the discourse within the online conversations could be attributed to only 1 or 2 participants. While the tool provides unique opportunities for mediating physics learning, it appears that additional intervention may be necessary to support a more meaningful learning experience.

Strand 6: Science Learning in Informal Contexts
Related Paper Set - The Role of Informal Experiences in Supporting STEM Interest
1:00pm - 2:30pm, Grand A
Presider: John H. Falk, Oregon State University
Discussants:
Christina Restrepo, Michigan State University
Day Greenberg, Michigan State University
Deborah Bailey, Oregon State University
Emily Dawson, King's College London
Jennifer Dewitt, King's College London
Jennifer Wyld, Oregon State University
Louise Archer, King's College London
Lynn Dierking, Oregon State University
Myunghwan Shin, Michigan State University
Nancy Staus, Oregon State University
ABSTRACT:
Interest has been shown to be a key variable in determining whether or not children pursue STEM opportunities both in and out of school as well as future participation in STEM as a career. Children with well-developed interests are more likely to engage in a number of actions typically associated with STEM learning. Importantly, individual interest, like learning in general, develops over time and across multiple settings. Informal experiences in particular have postulated as important vehicles for building and supporting children's interests in STEM. The five papers in this set explore research on STEM interest conducted across multiple informal settings and situations. Included are papers on the foundations of science interest in young children, the development of science and engineering interest and identities in youth from non-dominant populations, an effort to document early adolescent's long-term interest and engagement pathways, a comparison of different approaches to measuring STEM-related interests and the role that field trips to science museums play in building children's interest and science capital. Collectively, these papers provide a snapshot of the diverse and important research on STEM interest currently being conducted in informal contexts.

Comparing Different Approaches to Measuring STEM-Related Interests
Julie Cafarella, University of Colorado Boulder
William R. Penuel, University of Colorado
Nancy Staus, Oregon State University
Jennifer Wyld, Oregon State University
Deborah L. Bailey, Oregon State University
Lynn D. Dierking, Oregon State University
John H. Falk, Oregon State University

Documenting Early Adolescent Youth's Long-Term STEM Interest and Engagement Pathways
Lynn D. Dierking, Oregon State University
John H. Falk, Oregon State University
Nancy Staus, Oregon State University
Jennifer Wyld, Oregon State University
Deborah L. Bailey, Oregon State University
William R. Penuel, University of Colorado

Authoring Identity Pathways among Youth from Non-Dominant Backgrounds through Engineering for Sustainable Communities
Angela Calabrese-Barton, Michigan State University
Christina Restrepo, Michigan State University
Myunghwan Shin, Michigan State University
Day Greenberg, Michigan State University
Edna Tan, University of North Carolina at Greensboro

Science Museum Field Trips and Their Contribution to Developing Interest and Science Capital
Amy Seakins, King's College London
Jennifer Dewitt, King's College London
Emily Dawson, King's College London
Louise Archer, King's College London

Foundations of Science Interest Development in Young Children
Scott Pattison, Oregon Museum of Science and Industry
Lynn D. Dierking, Oregon State University

Strand 7: Pre-service Science Teacher Education
Socioscientific Issues, Argumentation and Teacher Preparation
1:00pm - 2:30pm, Grand Suite 5
Presider: Maria Evagorou, University of Nicosia

Preservice Science Teachers' First Experiences with Socio-scientific Discourse: The Problems and Possible Solutions
Umit Demiral, Ahi Evran University
Tezcan Kartal, Ahi Evran University
Ahmet Kilinc, Abant Izzet Baysal University
ABSTRACT:
The scholars and curriculum makers ask science teachers to organize socioscientific discourses to reach promising learning outcomes of SSI-based education. Existing literature shows that teachers are struggled to organize such discourses due to a range of problems such as limited experience about argumentation processes, time limitations and so on. However, this literature is based mainly on teachers' interviews and researchers' suggestions. In the present study, distinct from existing literature, we try to investigate the struggles that a preservice science teacher (PST) encounter during her first experiences about SSI discourse in real classrooms. In addition, we suggest solutions that we notice within the experiences of one another PST. For selecting these extreme cases, two observers grade 13 PSTs' SSI discourses using an extented Diaological Inquiry Tool. We select two PSTs (Duygu: lowest score, Esra: highest score) afterwards. We also conduct follow-up stimulated

recall interviews with these PSTs. Three authors independently watch the videos of these PSTs and scrutinize the interview transcripts using constant-comparative analysis. The results show that Duygu encounter with a range of problems such as limited subject matter knowledge, lacking meta-discourse explanations, problematic nominations of students, and so on. Upon explaining these problems, we suggest possible solutions using Esra's teaching practices.

Preservice Science Teachers' Socioscientific Issues-Based Teaching Practices in a Science Methods Course
Mustafa S. Topcu, Yildiz Technical University
Abdulkadir Genel, Mugla Sitki Kocman University
ABSTRACT:
In spite of increasing research and curriculum reforms including Socioscientific Issues (SSI) across the world, the question of how science teachers or teacher educators can teach SSI in science classrooms still needs further inquiry. In the present study, we explored the nature of 32 preservice science teachers' SSI-based teaching practices in a science methods course. An interpretive qualitative research approach was used in the study. In order to explore PST's SSI-based teaching practices, lesson plans developed by PST and video-tape recorded lessons were utilized. Our findings showed that all PST used media effectively and most of the arguments were at good level in their SSI-based teaching. Some of the PST were able to address the moral aspect of SSI and utilize risk statistics. The findings of this study also confirmed that PST are not having any difficulty in incorporating SSI topic to the unit topics. In conclusion, we can infer that science method course is effective in preparing PST to teach SSI by inclusion SSI in the course and probably is the best way. These findings might encourage other studies that aim to improve SSI teaching practices. We also think that our finding might affect the curriculum developers and policymakers.

Relating Preservice Teachers' Knowledge of Scientific Practices, Epistemic Aims and Values, and Self-Efficacy
Janelle M. Bailey, Temple University
Doug Lombardi, Temple University
ABSTRACT:
Instruction is related to the beliefs of the teacher, and the nature of instruction in turn can affect student learning. Sophisticated understanding of the nature of scientific knowledge is needed to effectively teach science. In this exploratory study, we investigated the relationship between preservice teachers' knowledge of scientific practices, epistemic cognition, and self-efficacy for teaching in their field. We will also looked for differences between an advanced and introductory science methods course in these variables. Results showed that the advanced science methods course had appreciably greater knowledge of scientific practices. Additionally, a regression model showed a statistically significant predictive relationship between knowledge of scientific practices, epistemic aims and values, and self-efficacy for science teaching. More importantly, knowledge and epistemic aims predicted more than half the variance in self-efficacy scores. By investigating this relationship, we begin to better understand preservice teacher beliefs and how knowledge of scientific practices, epistemic cognition, and self-efficacy interplay.

Supporting Elementary Students to Construct Evidence-Based Claims: Learning during a Practice-Based Science Methods Course
Anna Maria Arias, University Of Michigan
Elizabeth A. Davis, University of Michigan
ABSTRACT:
New reforms in science education call for learning scientific practices (e.g., constructing evidence-based claims) integrated with science content, yet facilitating this type of learning requires complex teaching that does not happen often in U.S. elementary classrooms. To support beginning teachers' learning of this complex work, a practice-based approach to teacher education has been suggested. This study examined how preservice

teachers learn to support elementary students in constructing evidence-based claims in science during a practice-based science methods course. During the course, preservice teachers' moves for facilitating this scientific practice showed both growth and challenges. For example, all five focal teachers supported their students to construct evidence-based claims and connected these claims to scientific principles in their final assignment. However, variation existed in the supports used to do this work and the scientific accuracy of their instruction. This work has implications for supporting teachers through professional development and preservice teacher education.

Strand 8: In-service Science Teacher Education
Examining Science Teachers' Beliefs and Attitudes
1:00pm - 2:30pm, Randolph
Presider: Jazlin Ebenezer, Wayne State University

Science Teachers' Beliefs about the Practices of Science as they Relate to Classroom Teaching
Kirby Browning, Florida State University
Anna M. Strimaitis, Florida State University
Jennifer Schellinger, FSU
Shannon Gooden, Florida State University
Sherry A. Southerland, Florida State University
ABSTRACT:
National reform efforts describe the need to engage students in the practices of science in order to gain a deeper conceptual understanding. To achieve these goals teachers need to be presented with more than a set of prescribed instructional strategies, they must understand the practices and value their application in the classroom. This study investigated 18 secondary science teachers' beliefs related to the implementation of these practices in classroom instruction. The findings suggest that while the majority of teachers deemed scientific practices as more important than tradition instructional strategies, but this did not translate into classroom use. Indeed, interviews revealed that many teachers held misconceptions about the practices of science, thought they were only "good" for teaching general skills, or listed implementation barriers. These results give insight into how to better tailor professional development efforts to support the use of the practices within the classroom.

Construct Validity and Reliability Measures of Scores from the Science Teachers' Pedagogical Discontentment (STPD) Scale
Murat Kahveci, Canakkale Onsekiz Mart University
Ajda Kahveci, Çanakkale Onsekiz Mart University
Nasser Mansour, University Of Exeter
Maher M Alarfaj, King Faisal University
ABSTRACT:
The Science Teachers' Pedagogical Discontentment scale has formerly been developed in the United States and used since 2006. Based on the perceptions of selected teachers, the scale is deeply rooted in the cultural and national standards. Given these limitations, the measurement integrity of its scores has not yet been conclusively established internationally, such as in the Saudi Arabia context. The items of the scale are slightly tailored to make the instrument suitable in the specific context, such as with respect to country-based regulations, reforms, and everyday practices of science teachers and their professional development initiatives. Item-based descriptive statistics, the measure's factor structure as opposed to its former validity studies, and factor-based reliability scores are investigated in the present report. Thus, this study extends the validity and reliability measures of the instrument to the international scale and further confirms its appropriateness to measure teacher attitudes towards inquiry-based science education initiatives.

Self-efficacy Beliefs for Teaching Physics – Development and Validation of a New Test Instrument
Claudia Meinhardt, Martin-Luther-Universität Halle-Wittenberg
Thorid Rabe, Martin-Luther-Universität Halle-Wittenberg
Olaf Krey, Martin-Luther-Universität Halle-Wittenberg
ABSTRACT:
Science teachers' self-efficacy is considered to be a central variable in order to predict science teachers' classroom management, students' self-efficacy beliefs and their achievement. Nevertheless there is an ongoing discussion about the appropriate sense of specificity of current instruments and also about their validity and reliability. A theoretically well grounded test instrument has been designed to measure physics teachers' self-efficacy beliefs in the fields of "experimenting", "analyzing and preparing physics contents", "using exercises/problems" and "dealing with students' conceptions". For each of these fields two scales in the dimensions "planning" and "conducting" (physics lessons) have been developed. Both, results of several pilot studies and of a bigger main study show by means of statistical analysis (CFA, correlation analysis) and qualitative methods (interviews, expert rating), that it is possible to develop an instrument for this level of specificity and indicate how items can be improved for the final test instrument. Selected findings of each study are presented in the paper.

Revealing Folk Theories of Scientific Knowledge through Conversations about a Multi-Dimensional Learning Progression
Rajendra Chattergoon, University of Colorado, Boulder
ABSTRACT:
Learning progressions are research-based hypotheses of the successively more sophisticated ways of thinking that students are likely to follow as they investigate a topic. They represent a possible alternative to conventional content standards, but much remains unknown about how teachers use learning progressions to connect student learning, instruction, and assessment. The present study explores how six biology teachers' descriptions of student ideas relative to a multi-dimensional learning progression for natural selection revealed their beliefs about scientific knowledge. These teachers conceptualized scientific knowledge as right or wrong in a majority of cases, lending support to the claim that these teachers had a common belief in a standard scientifically correct idea. When using the multi-dimensional learning progression to describe student ideas, these teachers may have drawn upon the belief in a standard scientific answer to collapse the dimension of the learning progression that described a continuum of students' naive ideas into binary categories of correct and incorrect. The absence of rich conversations about students' misconceptions compromised effective use of the learning progression. Researchers and policy makers need to examine the connection between how teacher beliefs inform the use of learning progressions to better equip educators in the use of these new tools.

Strand 8: In-service Science Teacher Education
Related Paper Set - Working towards Change: Supporting In-service Teachers' Enactment of NGSS
1:00pm - 2:30pm, Grand Suite 3
ABSTRACT:
The papers in this set reflect efforts to provide in-service teachers opportunities to make sense of the scientific practices as defined by the NGSS. Paper 1 presents a study of teachers learning in a video club setting in which they view and discuss video of students engaged in the NGSS practices. Paper 2 presents a study of teachers examining and discussing a student artifact reflecting their students' thinking while engaged in the NGSS practices. Paper 3 explores how embedded literacy supports are taken up during planning and instruction, and the implications of their use on students' engagement in scientific practices and the development of disciplinary core ideas. Paper 4 uses a design-based research perspective and describes both the challenges and designed

responses to an effort to promote text-based inquiry as a means of building explanatory models. Taken together, these studies aim to address the following research questions: (1) What is the nature of teachers' understanding of the practices outlined in the standards? (2) How do teachers take up the instructional tools intended to support the practices?,(3) What are the implications of these findings on the design of supports for teacher learning around the practices?

Text-based Inquiry for Scientific Modeling
Mon Lin Ko, University of Illinois Chicago
Willard Brown, WestEd
Cynthia Greenleaf, WestEd
Susan R Goldman, University of Illinois Chicago

Noticing Students' Thinking and the NGSS Practices in Student Artifacts
Melissa Luna, West Virginia University
Sarah Selmer, West Virginia University
James A Rye, West Virginia University

Video Club as a Context for Shifting Discourse about Scientific Practices
Heather J. Johnson, Vanderbilt University
Michelle Cotterman, Vanderbilt University

Teachers' Instructional Strategies that Support Literacy as a Scientific Practice
Kirsten K. Mawyer, University of Hawaii

Strand 10: Curriculum, Evaluation, and Assessment
K-8 Education
1:00pm - 2:30pm, Water Tower
Presider: Joi Merritt, Arizona State University

Supporting Preschool Scientists: Designing Innovative Curricular Tools to Support Early Science Teaching and Learning
Ximena Dominguez, SRI International
Marion Goldstein, EDC
Elica Sharifnia, SRI International
Daisy Rutstein, SRI International
Regan Vidiksis, EDC
Christine Zanchi, WGBH
ABSTRACT:
This paper discusses findings from the initial phases—the iterative design and development phases—of a federally funded preschool science project that aims to develop, iteratively refine, and evaluate an innovative program to promote young children's understanding of science concepts, engagement in science practices, and use of scientific discourse. The program (1) integrates activities that rely on common preschool formats (e.g., circle-time activities, book readings, and hands-on investigations) with developmentally appropriate digital activities that capitalize on the unique affordances of technology and media to promote science teaching and learning (e.g., a digital toolkit that supports practices such as documentation via photographs and videos, simulations that introduce topics and deepen learning, and games that provide opportunity for repeated practice) and (2) includes strong professional development resources to support teachers and guide classroom

implementation. This paper describes the evidence-based, iterative design process employed and reports on findings from a field study in preschool classrooms serving children from low-income families. More specifically, it describes how findings from classroom observations are informing revisions to the design of curricular activities and how findings from child assessments are informing revisions to the Evidence Centered Design assessment being developed to examine young children's science learning.

Multilevel Assessment of Interest in Health Careers at the Middle School Level: Introducing the AIMS
William L. Romine, Wright State University
Amber Todd, Wright State University
William R. Folk, University of Missouri
ABSTRACT:
We describe the development of the Assessment of Interest in Medicine and Science (AIMS) and its validation through three rounds of data collection and revision. The AIMS was developed and validated on middle school students in the context of an inquiry-based instructional unit on eye care. A multi-level assessment framework was used to define interest. Interest in science was furthest away from the curriculum. Interest in medicine was closer, and interest in eye care was closest. Using ordinal confirmatory factor analysis and Rasch procedures, we found that the three scales provided unidimensional, valid, and reliable measures for interest in middle school students at various distances from the curriculum. A majority of the items fit well with the Rasch model, and scale reliabilities were found to be well above 0.8, indicating sufficient precision for individual comparisons in the context of health interventions. However, the data suggested that room still exists for improvement of the AIMS. Suggestions for improving the wording of certain items toward further improving measurement validity of the AIMS are discussed.

Using Rasch Modeling to Explore Students Understanding of Elementary School Ideas about Energy
Cari F. Herrmann Abell, AAAS/Project 2061
George E. De Boer, AAAS/Project 2061
ABSTRACT:
Energy plays a central role in our society, so it is essential for all citizens to understand what energy is and how it can be transformed and transferred. However, research has shown that students of all ages have difficulty understanding this abstract concept. This paper presents a summary of elementary, middle, and high school students' understanding of elementary school energy ideas. This work is part of a larger project to develop three vertically equated instruments to measure students' progression on the energy concept. The data presented here are from the field test of distractor-driven multiple-choice items aligned to elementary-level ideas about the forms of energy and energy transfer. These items were tested with all three grade bands, even though they explicitly test elementary ideas. A total of 3037 students in grades four through twelve from the US participated, and Rasch modeling was used to analyze the data. Option probability curves represented the distribution of correct answers and misconceptions across the range of student knowledge levels. The shapes of the curves and where they occur as a function of knowledge level suggest a progression of misconceptions that appear and disappear in sequence as students become more knowledgeable about energy.

They Can Do It! Designing Curricula to Support Kindergarteners' Learning of Science
Amelia Wenk Gotwals, Michigan State University
Tanya Wright, Michigan State University
ABSTRACT:
Despite strong evidence that young children are motivated by and capable of learning that integrates science practices, crosscutting concepts, and disciplinary core ideas, there continues to be limited attention to science instruction in kindergarten. Likewise, despite evidence of the importance of early exposure to informational texts to promote young children's oral language and comprehension development, these areas also remain

neglected. Therefore, in order to meet ambitious new science and language and literacy standards, there is a critical need to develop curriculum materials that support teachers in providing instruction in these key academic areas from the start of formal schooling, kindergarten. This study examines the enactment of two four-week kindergarten curricular units that align with the Next Generation Science Standards (NGSS) and standards for disciplinary language and literacy. Findings suggest that students who participated in the curriculum held much deeper understandings of the science content than similar students in other classrooms. In addition, analysis of discussion in classrooms enacting the curriculum showed instances of teachers supporting students in using evidence to support claims and develop explanations of phenomena – practices central to the NGSS. This suggests we can design curricula to support our youngest students in reaching the ambitious NGSS performance expectations.

Strand 10: Curriculum, Evaluation, and Assessment
Symposium - Designing Assessments Aligned with Current Science Education Reforms
1:00pm - 2:30pm, Comiskey
Presider: Marcia C. Linn, University of California-Berkeley
Discussant: Jonathan Osborne, Stanford University
Presenters:
Edys S. Quellmalz, WestEd
Helen Zhihui Zhang, Boston College
Hsin-Yi Chang, National Kaohsiung Normal University
Anna MacPherson, Stanford University
Kihyun (Kelly) Ryoo, University of North Carolina, Chapel Hill
Libby Gerard, University of California, Berkeley
Barbara C. Buckley, WestEd
Matt Silberglitt, WestEd
ABSTRACT:
Measuring scientific practices and cross-cutting themes that lie at the heart of Next Generation Science Standards (NGSS) requires a substantial effort to create new assessments that tap argumentation, systems thinking, causal reasoning, modeling, and related capabilities. Assessment is a vital tool in communicating the intent of the curriculum. Teachers often infer instructional goals not from syllabi or curriculum documents but from the items used to measure student achievement. Assessments can extend the curriculum by engaging students in valuable activities that also yield indicators of progress rather than interrupting learning to document achievements. We highlight five perspectives on science assessment to stimulate discussion and debate about alternative ways to assess the NGSS. These perspectives take advantage of simulations, automated scoring, and related technologies. They highlight perplexing questions about the connections between assessment and instruction, learning, professional development, and science standards. This symposium will feature panel presentations followed by opportunities for others to add perspectives. The presider will engage participants in identifying a research agenda that can inform the field. This symposium addresses the conference theme by featuring international participants, connecting to the NGSS standards, and drawing on sound research that highlights diverse solutions to the challenge of science assessment.

Strand 11: Cultural, Social, and Gender Issues
Symposium - An International Perspective on Decolonizing Research Methodologies in Science Education
1:00pm - 2:30pm, Grand D North
Presider: Alberto J. Rodriguez, Purdue University
Discussant: Christina Siry, University of Luxembourg

ABSTRACT:
This session brings together international scholars from six different countries interested in sharing the challenges and successes of conducting science education research in the complex, and often contradictory, contexts in which we do our work with the Other. From working with young children, to working with teachers and student teachers, to exposing colonial research funding policies, these papers interrogate colonial, masculine and taken-for-granted assumptions that continue to undermine the advancement of our field. The interactive format of the symposium aims to engage participants in a productive conversation that will evoke reflection and promote transformative change.

Promoting Participant-Owned Science Education Research: Lessons From Experiences in Brazil, Ireland and Sweden.
Isabel Martins, Federal University of Rio de Janeiro, Brazil
Karim Hamza, Stockholm University, Sweden
Colette Murphy, Trinity College Dublin, Ireland

Communicating Through Silence: Examining the Unspoken and the Unsaid in Discussions about Science
Katheryn Scantlebury, University of Delaware
Anita Hussenius, Uppsala University
Annica Gullberg, Gavle University
Anna Danielsson, Uppsala University

Can we Capture "Everything"? Questioning what is Left out in the Research Process
Jana Maria Hilgers, University of Luxembourg

Colonial Research Funding Policies and Practices and their Impact on the Advancement of Science Education in the USA
Alberto J. Rodriguez, Purdue University, USA

Strand 12: Educational Technology
Educational Technology and Enactment
1:00pm - 2:30pm, Columbus KL
Presider: Dorene R. Medlin, Albany State University

Benefits of an Online Video Competition for Participants, Community Members, and the Public
Rena Stroud, TERC
Joni Falk, TERC
ABSTRACT:
This paper explores the value of an online video and poster science competition created for graduate students engaged in interdisciplinary Ph.D. programs funded through the National Science Foundation. Many of the lessons learned may be appropriate for undergraduate and high school competitions designed to engage students in communicating their science through video and sharing their work with a large public audience through social media. We examine the success of such an event in terms of: 1) Broad scale dissemination of cutting edge science to the public at large, 2) A worthwhile professional development experience, 3) A mechanism for students to view each other's work and to receive faculty and peer feedback, 4) Effective use of video as a tool for sharing scientific research. Students, working individually or in teams, presented 119 presentations, each including a poster and three-minute video highlighting their interdisciplinary research. In addition, each presentation had a discussion area for dialogue between presenters and judges, as well as a general discussion

for all visitors to the presentation. Winners were selected by faculty judges, and through community choice votes, and public choice votes. The competition platform, including all videos, posters, and discussions, remain available to the public at http://posterhall.org/igert2013.

Synergy: How Generic and Content-Specific Scaffolds Support Quality of Students' Explanations

Ibrahim Delen, Michigan State University
Joseph S. Krajcik, Michigan State University

ABSTRACT:
Synergy can be thought of as generic and content-specific scaffolds working together to enable students to accomplish challenging tasks, such as creating explanations that they would not normally be able to do without the scaffolds working together. In this study, we examined the synergy when the teacher supported students' understanding of claim-evidence-reasoning framework (part The second component of examining synergy (part 2: using mobile devices) investigated how a teacher used mobile devices to provide feedback when students created explanations. The synergy between providing instruction and using mobile devices was investigated by analyzing a middle school teacher's practices in two different units (plants and water quality). Findings of this study showed that the decrease in the teacher's support for claims, did not affect the quality of the students' claims. On the other hand, the quality of students' reasoning were linked with the teacher's practices. This suggests that when supporting students' explanations, focusing on components that students find challenging would benefit students' construction of explanations. To achieve synergy in this process, the collaboration between teacher's practices, professional development sessions and scaffolds designed to support teachers played a crucial role in aiding students in creating explanations.

Inferences on Enacted Understandings: Using Embodied Interactive Simulations to Examine Emerging Understandings of Science Concepts

Robb Lindgren, University of Illinois Urbana-Champaign
Michael Tscholl, University of Wisconsin Madison

ABSTRACT:
In this paper we describe an approach to examining and potentially diagnosing middle school students' preconceptions and emerging understanding about science concepts using immersive and interactive simulations. Specifically we examine whether embodied simulations can allow for making "inferences on enacted understandings," as opposed to using traditional paper and text-based inventories. Using an immersive simulation of planetary astronomy, we describe a coding scheme and associated dataset showing a nuanced categorization of behaviors that are indicative of primitive and emerging concepts. Based on commonly exhibited physical behaviors we are able to make some inferences about typical forms of understanding for this specific topic area. We give examples of these inferences and discuss briefly how these same diagnostic environments may be used for instruction and remediation.

Investigating Preservice Teacher Learning to Facilitate Inquiry-Based Science Instruction in a Mixed-Reality Classroom

Nazan U. Bautista, Miami University
Vanashri J. Nargund-Joshi, New Jersey City University

ABSTRACT:
The purpose of this study was to explore how preservice early childhood teachers' understanding and implementation of science inquiry changed as they practiced teaching in a mixed-reality teaching environment, called TeachLivE™ Lab (TLE). Preservice teachers' understanding of characteristics of an effective science instruction and beliefs and understanding about inquiry-based teaching were studied through written reflections and interviews. Twenty-five early childhood preservice teachers participated in the study. Overall, the results suggest that the TLE is a worthwhile technology for learning to teach science through inquiry. It provides a way

for PSTs to have a highly personalized learning experience that enables them to improve their understanding of inquiry science and confidence in teaching science, so that, ideally someday they may translate such an experience into their classroom practices.

Strand 12: Educational Technology
Symposium: Big Data and Learning Analytics: A New Frontier in Science and Engineering Education Research
1:00pm - 2:30pm, Columbus GH
Discussant: Janet Kolodner, Georgia Tech
Presenters:
Hee-Sun Lee, University of California, Santa Cruz
Saeid Nourian, Concord Consortium
Kyle R. Cheney, WPI
Raha Moussavi, Worcester Polytechnic Institute
Janice Gobert, Worster Polytechnical Institute
Charles Xie, Concord Consortium
Gey-Hong Gweon, University of California, Santa Cruz
James Lester, North Carolina State University
Eric N. Wiebe, North Carolina State University
ABSTRACT:
One of the noticeable societal trends caused by the rapid rise of computing power is the availability of big data. From the perspectives of four research projects, this symposium addresses an overall question of what big data and associated learning analytics mean to science education research and science teaching and learning in the classroom. Despite differences in science teaching and learning contexts where these projects are situated, they all face similar challenges in (1) identifying constructs of student cognition to promote in technology-enhanced learning environments, (2) creating capacities to collect meaningful data that can be automatically collected in the environments, (3) analyzing a large amount of learning data produced by students as effectively and meaningfully as possible, and (4) visualizing and using results of analyzed data to inform decisions teachers, students, curriculum developers, and researchers make. Each presenter will address these aspects and discuss related findings and future directions. This array of projects will provide the breadth and depth necessary to introduce big data and learning analytics to the community of science education researchers who are interested in implementing them in their own research.

Strand 13: History, Philosophy, and Sociology of Science
In-Service Education
1:00pm - 2:30pm, Gold Coast
Presider: Bridget K. Mulvey, Kent State University

The Impact of a Biology Teacher Professional Development Program on Nature of Science Understanding and Knowledge of NOS Instructional Strategies
Hernan Cofre, Pontificia Universidad Católica de Valparaíso
Jose M Pavez, Pontificia Universidad Católica de Valparaíso
Claudia Vergara, Universtity Alberto Hurtado
David Santibáñez, Universidad Catolica Silva Henriquez, Chile
ABSTRACT:

Understanding nature of science (NOS) is considered critical to the development of students' scientific literacy. However, various studies have shown that a large number of elementary and secondary science teachers do not possess an adequate understanding of NOS. This study investigated how biology teachers' understanding of NOS was impacted through a professional development program in Chile. Sixteen teachers attended a professional development program focused on science methods courses and NOS courses. The VNOS D+ questionnaire and interviews were used to assess teachers' understanding of NOS at the beginning and end of the program. Biology teachers' understanding of the most of aspect of NOS showed an improvement, specially the multiples methods, creativity, observation and inference and empirical NOS. The improvement in each NOS aspect was related with the number of activities that target the NOS aspects explicitly. According to the teachers' perceptions, both kinds of activities (decontextualized and contextualized) were important for improving their NOS understanding, however, they had problems to planning and include NOS embedded within their biology lessons. Even though most of teachers initially adopted an implicit or didactic teaching of NOS, at the end of the program, many of them included in a more explicit way NOS instruction.

Special Education Teachers' Initial Inquiry and Nature of Science Teaching Experiences

Bridget K. Mulvey, Kent State University
Jennifer Chiu, University Of Virginia
Rajlakshmi Ghosh, Kent State University
Randy L. Bell, Oregon State University

ABSTRACT:
SPED teachers provide critical instruction to science students. However, little research investigates SPED teacher beliefs and practices around inquiry and the nature of science (NOS). This investigation is a case study of 4 SPED teachers' initial semester-long experiences learning about and attempting to implement inquiry and nature of science instruction. From a study of 61 preK–5 teachers who completed a semester-long PD, all SPED teachers were selected as participants for the present investigation. Data sources included pre/post surveys, lesson video recordings, guided reflections, and post-course interviews. Results indicated that all participants improved their NOS views, explicitly covered NOS during instruction, and successfully taught via inquiry, moving beyond course lessons they experienced to adapt them to students' needs and sometimes innovate new lessons. Teachers increased the use of divergent questioning and reflective discussions about scientific inquiry, NOS and science content through time and instructional concerns shifted slightly from logistics to pedagogy. Results suggest that SPED teachers can benefit from targeted science PD. Also, SPED teachers in inclusion settings may need additional support negotiating roles with the other classroom teacher to better meet students' varied needs. Results may help to inform preservice teacher science methods courses and inservice teacher PDs.

Uganda Science Teacher Educators' Views on Nature of Scientific Theories, Observations and Inferences

Robert E. Kagumba, Western Michigan University
William W. Cobern, Western Michigan University
Renee S. Schwartz, Georgia State University

ABSTRACT:
Science education reformers advocate for learning and teaching nature of science to promote learners' interest in science and scientific literacy. In the case of Uganda, although it has adopted current science education reforms, there is a dearth of literature on the conception, teaching and learning of nature of science in Uganda. This study seeks to document Uganda science teacher educators' knowledge on nature of scientific theories, and nature of scientific observations and inferences. Mixed methodology including surveys, telephone interviews and content analysis of science methods syllabi provide data on 63 study subjects. Descriptive profiles of their knowledge on two aspects of nature of science were generated. Generally, subjects' understanding of these aspects is transitional, and objectivist in nature. Most conceive that there are 'grounded' scientific theories that never change and some which change to become scientific laws and principles. Along the same line, they

believe that independent scientific observations of a natural phenomenon are always the same although different inferences may be drawn from them. A distinct but small number of subjects possess the goal conceptions for the two aspects of nature of science. These study findings contribute to global science education research, and are useful toward science teacher education curriculum and professional development in Uganda

Changing Elementary Teachers' Motivational Beliefs about Teaching Nature of Science
Elif Adibelli, University of Nevada, Las Vegas
Hasan Deniz, University of Nevada, Las Vegas
ABSTRACT:
This qualitative study aimed to explore the changes in motivational beliefs about developmental appropriateness and importance of NOS throughout a year-long professional development program. The multiple embedded case-study design was employed to explore the changes in teacher beliefs about developmental appropriateness and importance of teaching NOS in depth and within the context of the elementary school setting. Four elementary teachers participated in the study. The professional development program, which was particularly designed for elementary teachers used an explicit-reflective approach to teach NOS and provided multiple contexts by combining biweekly academic year workshops that introduced NOS aspects and teaching strategies with on-going support as teachers integrated these new ideas into their own classrooms. Data collected from multiple sources (questionnaires, interviews, videotaping of teacher meetings, artifacts, and field notes) were analyzed using pattern matching, explanation building, and cross-case synthesis. The findings showed that at the beginning participants considered most NOS aspects appropriate and important to teach for their own students. Participating in NOS training provided opportunities for participants to strengthen their existing motivational beliefs. Teaching NOS in the classroom, however, presented concrete evidence for participants about their students' ability to learn NOS, which in turn helped them to change their motivational beliefs.

How In-service Science Teachers Integrate History and Nature of Science in Elementary Science Courses
Esme Hacieminoglu, Necmettin Erbakan University
ABSTRACT:
The purpose of this study is to investigate the in-service science teachers' (ISTs) perceptions and practices about curriculum and integration of history of science (HOS) and nature of science (NOS) in their science course. In this phenomenological study purposeful and criterion sampling methods were used. Nine ISTs constituted the sample of the study. A constant comparative method was utilized for the data analysis. Multiple data sources and different evaluators were used for triangulation. The current study revealed that all the teachers in this study do their best to implement the science and technology curriculum; however, the implementation of the curriculum is not at the expected level. Also our findings indicated that teachers' views about NOS did not directly influence their educational practices. Besides, knowing how to teach NOS is important factor for teachers transferring their knowledge and understanding of NOS to their classroom practices as well as teachers NOS views. In this process some possible problems such as creating misconceptions, not explaining the NOS aspects effectively, the students' beliefs and individual differences, and the classroom environment might emerge and negatively affect the teachers' integration of NOS and HOS. Article was published in Educational Science: Theory & Practices, 14(1), 353-372.

Strand 15: Policy
Policy in Context: Intersections with Critical Networks, Actors and Practices
1:00pm - 2:30pm, Columbus AB
Presider: Gavin W. Fulmer, National Institute of Education

Supporting Newly Hired Teachers of Science: Attaining Teacher Professional Standards

Julie A. Luft, University of Georgia
Shannon Dubois, The University of Virginia
Ryan Nixon, University of Georgia
Benjamin Campbell, University of Georgia

ABSTRACT:
Newly hired teachers, recent graduates, or beginning teachers have captured the interest of teacher educators and policy makers. Teacher educators are increasingly interested in how their teachers preform in their early years, while policy makers are creating guidelines for science teacher preparation and induction. This review of research is in response to the increased attention that has been given to newly hired science teachers. The articles in this review were analyzed using a framework developed by examination of standards from different countries that pertained to newly hired teachers of science (NHTS). Over 100 articles, spanning 30 years, were identified for this review. Guidelines for selection of the articles were based upon the American Educational Research Association guidelines for research publications, Bybee's (1982) guidelines for reviewing older work, and Clarke, Triggs, and Nielson's (2013) review of research. In this review of research, there are five areas that frame the identified studies on NHTS: Content and Curricular Knowledge, Learners and Learning, Professional Practice/Learning Environments, Equity, and Assessment. The review of research has specific suggestions about attaining the standards, per the research, and there are specific suggestions for future research.

At the Policy-Research Interface: Usefulness of Social Network Analysis in Identifying and Selecting Key Stakeholders

Jesper Bruun, Department of Science Education
Robert H. Evans, University of Copenhagen
Jens Dolin, University of Copenhagen

ABSTRACT:
Educational researchers often aim for their research to be used to inform and change practice. But experience tells us that it is not easy for research to affect policy. A central goal in the high-level European research project, ASSIST-ME (Assess Inquiry in Science, Technology and Mathematics Education), is to formulate guidelines and recommendations for policy makers, curriculum developers, teacher trainers and other stakeholders in European educational systems. This use of research results is organized through National Stakeholder Panels established to advise and provide professional development on how best to impact policy and practice. In this paper, we report on a method to map out networks of relevant stakeholders and use Social Network Analysis to select key stakeholders to invite to National Stakeholder Panels in seven European countries. Our analysis shows that size and coherency of networks are crucial factors when project partners use Social Network Analysis reports to select members to invite to National Stakeholder Panels. Other factors, such as perceived bias in the kinds of stakeholders and lag of knowledge of stakeholders in the networks are also important. The results are useful to researchers who want to engage with systematic mappings of stakeholders for science educational policy projects.

Teacher Responses to Science Content in an Externally Driven Curriculum Reform: A Perspective from Turkey

Fatih C. Mercan, Bogazici University

ABSTRACT:
In Turkey, as part of an externally driven state mandated science curricular reform, the secondary school physics, chemistry, and biology curricula were renewed in 2008. Although limited, the existing research base shows that the enactment of such reforms rarely reflects the intended outcomes of curriculum developers. This study aims to provide a holistic account that considers not only teachers' personal beliefs and knowledge but also structural features of school teaching and broader contexts of educational policy. The participants were 99 teachers employed in 27 different state secondary schools in Istanbul during the year 2011. The data were collected by conducting semi-structured interviews and were analyzed by employing the constant comparative

method. The data showed that teacher responses to the content of curriculum spanned a wide range, involving personal, internal and external frames of references on content scope, sequence, continuity, articulation, and balance. External factors such as high stakes testing seem to heavily regulate teacher responses to curriculum content, even in the absence of external accountability measures for teachers. The results also support the idea that teachers co-construct policy in their school workplaces. Hence, providing opportunities for mutual reflection between teachers and curriculum developers is recommended.

Science Coordinators: An Important Leadership Group
Elizabeth W. Edmondson, Virginia Commonwealth University
ABSTRACT:
Studies indicate that district leadership and district initiatives have a significant effect on principal, teacher, and student learning outcomes (Copland & Knapp, 2006; Honig, 2006; Leithwood & Wahlstrom, 2008; Wahlstrom et al., 2010). Few studies focus the impact of district science education leaders. This study will examine the participants' perceived role and impact within their district and the types of initiatives and professional activities implemented during and after participation in a 5 day professional development (PD) institute. Entrance and exit slips, activity logs, and science focused strategic plans were analyzed qualitatively. The participants through their reflections have indicated that they have a variety of perceived roles. They also have different perceptions of their ability to impact learning in their districts. This is not surprising as district needs across AA are diverse, as across the U.S. These new leaders have a diverse set of needs as seen by their use of different components of the DDDD. As we strive to improve schools and districts, we must not forget the learning needs of these leaders. They are an important piece of the puzzle.

Concurrent Session #13
2:45pm – 4:15pm

Strand 1: Science Learning, Understanding and Conceptual Change
Research on Learning in Biology
2:45pm - 4:15pm, Columbus GH
Presider: Sherry A. Southerland, Florida State University

The Use of Disciplinary Core Ideas and Contexts in Biology Lessons
Katharina Nachreiner, Ludwig-Maximilians-University Munich
Michael Spangler, Ludwig-Maximilians-University Munich
Birgit J. Neuhaus, Ludwig-Maximilians-University Munich
ABSTRACT:
One big challenge in Biology-classrooms is a load of discrete-unrelated facts. So, education-researchers recommended the inclusion of disciplinary core ideas (German: “Basiskonzepte”) to link these facts and facilitate in-depth understanding of biology concepts. Further challenges of science subjects are the lack of transfer and decreasing interest. Contexts have been successfully used to address these challenges in chemistry, but there exist only few results in biology. It is expected that the use of contexts raises the students´ situational interest and that disciplinary core ideas foster their conceptual understanding. Nevertheless it remains unclear if the inclusion of both together increases the level of cognitive load excessively. This study investigates the influence of disciplinary core ideas and contexts on 10th grade students´ interest and knowledge gain in a 2x2-design (N = 176 students in 7 classrooms). The knowledge gain was measured in a pre-post-design. The students answered questionnaires on their situational interest (N = 3, $\alpha = .80$) and cognitive load (N = 3, $\alpha = .89$). The preliminary data suggest that disciplinary core ideas lead to a greater knowledge gain, which is

supported by the qualitative analysis that shows a more detailed explanation from students taught following the disciplinary core ideas.

Using Scaffolding to Build Phylogenetic Trees with High School Students
Julie Bokor, University of Florida
Jacob Landis, University of Florida
Kent J. Crippen, University of Florida
ABSTRACT:
Tree thinking is a skill that can facilitate student understanding of biological evolution (e.g., Gregory, 2008; O'Hara, 1998). However, explicit phylogenetics instruction is seldom included in secondary classrooms. This paper describes the first two cycles of design-based research on a phylogenetics module during a STEM immersion program on a University campus. In Year One, we engaged high school students in a six-hour module incorporating molecular biology concepts and techniques as well as developing phylogenetic trees (Authors, in press). Content mastery was not a primary goal, however, after Year One, it was woefully obvious students did not understand how to construct or interpret phylogenetic trees. Therefore, our first revision focused on the addition of scaffolding to better support the development of conceptual understanding of phylogenetics as well as a broader understanding of biological evolution. For Year Two, two instruments were used pre/post to measure these learning outcomes. Additionally, student generated phylogenetic trees were scored as in Year One. Results indicated measurable improvement in tree construction and learning gains. However, there was no significant change in student conceptions of evolution. We believe this study can inform development of educative curricular materials and methods for integrating tree thinking into secondary classrooms.

Exploring Students' Evolutionary Explanations across Natural, Sexual, and Artificial Selection Scenarios
Minsu Ha, Kangwon National University
Ross H. Nehm, SUNY Stony Brook
ABSTRACT:
Despite the importance of sexual selection and artificial selection in the conceptual development of evolutionary thought and their ubiquity in textbooks, curricula, and scientific research, no studies to our knowledge have investigated students' thinking about these core ideas relative to natural selection. In this study, we explored the composition and structure of students' knowledge, naïve ideas, and reasoning models across natural, sexual, and artificial selection scenarios. We used an open-ended instrument to examine 393 students' evolutionary explanations across natural, sexual, and artificial selection scenarios before and after a class focused on evolutionary ideas. Participants totaled 393, with an average age of 19.4 years. MANOVAs of normative and naïve concepts were compared across contexts, as were descriptive statistics of types of ideas. While the KC scores showed weakly significant differences across scenarios ($F[2, 778] = 3.93$, $p = 0.020$, $\eta p2 = 0.010$), the NI scores showed strongly significant differences across NSA scenarios ($F[2, 778] = 58.98$, $p = 0.000$, $\eta p2 = 0.132$). Reasoning about natural and sexual selection showed the most conceptual similarity in normative and naïve ideas. We discuss implications for sequencing and teaching selective concepts in HS and college classrooms.

Mexican Nahua Students Learning about Natural Selection: The Role of Teleological Reasoning
Ingrid M. Sanchez-Tapia, University of Illinois, Chicago (UIC)
ABSTRACT:
Natural Selection (NS) is one of the most difficult ideas to learn in science courses, due to multiple factors, including teleological reasoning. Teleology has been demonstrated to be a prevalent reasoning pattern across cultures, calling for strategies to address it when teaching NS in diverse cultural settings. This paper explores the changes in teleological reasoning of 7th grade Nahua students in response to a curricular unit on NS. The

unit was contextualized in a culturally relevant manner, including traditional Nahua narratives and knowledge. Quantitative evidence derived from 1) pre/post interview focused on teleology, and 2) pre/post test scores from a test focused on content knowledge, indicates that the contextualization features included in the unit did not have an effect on the students' teleological reasoning, but did support them in learning Western science concepts such as inheritance, and to apply them when reasoning about plants and animals. Thus, the observed teleological bias does not seem to interfere in students' understanding and application of biological causal mechanisms, challenging the research literature on this topic. These findings have important implications for understanding how to better support students from diverse ethnic backgrounds to learn about a core idea in biology through culturally relevant curriculum.

Strand 1: Science Learning, Understanding and Conceptual Change
Symposium - Learning Progression-Based Systems to Support Environmental Science Literacy
2:45pm - 4:15pm, Columbus IJ
Presider: Charles W. Anderson, Michigan State University
Discussant: William Penuel, University of Colorado Boulder
Presenters:
Charles W. Anderson, Michigan State University
Jennifer H. Doherty, University of Washington
Elizabeth X. De Los Santos, Michigan State University
Joyce M. Parker, Michigan State University
Allison L. Freed, Michigan State University
Wendy R. Johnson, Michigan State University
Hannah K. Miller, Michigan State University
Daniel Gallagher, Seattle Pubic Schools
Beth Covitt
Jenny Dauer
ABSTRACT:
This thematic, interactive poster session presents results from a project that has been working since 2003 to develop and validate learning progressions leading to environmental science literacy. The project focuses on environmental science literacy for a particular domain: carbon-transforming processes in socio-ecological systems at multiple scales. This includes: cellular and organismal metabolism in plants, animals, and decomposers; energy flow and carbon cycling at ecosystem and global scales; carbon sequestration; and combustion of fossil fuels. The learning progressions in this domain supported development of six teaching units with supporting assessment systems on the National Geographic website. The seven posters in this session we report on how our initial learning progressions research has served as the foundation for (a) exploration of a wider range of science and engineering practices (including making explanations and predictions, interpreting and analyzing data and constructing arguments from evidence, and environmental decision making); (b) investigations of teachers' knowledge and practice; and (c) development of support networks and professional learning communities. The session includes a general introduction, opportunities for participants to visit and discuss individual posters, and a group discussion led by a well-known discussant.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Identity and Disciplinary Engagement
2:45pm - 4:15pm, Columbus KL
Presider: Jianlan Wang, Florida International University

Can Laughter Be The Best Medicine For Breaking Barriers To Students' Under-Achievement In Science?

Michael Ige, Lagos State University, Lagos, Nigeria
Peter A. Okebukola, Lagos State University
Olatunde Lawal Owolabi, Lagos State University
Sunday Banjoko, Lagos State University
Bunmi Ademola, Lagos State University
Innocent Ezedimbu, Lagos State University
Franklin Onowugbeda, Lagos State University
Cheta Ezeani, Lagos State University
Mariam Faniyu, Lagos State University
Blessing Abu, Lagos State University

ABSTRACT:
The goal of this study was to fill an important void by investigating how humor in teaching of science impacts on students' learning of difficult concepts in science in Nigeria. A mixed-method quasi-experimental design was employed involving a sample of 106 senior secondary class 2 students (57 boys, 49 girls; mean age 16.3 years) drawn from three schools in Lagos State, Nigeria to which the teachers were randomly posted for teaching practice. The topic –excretion, to which the study targeted is among those adjudged by the Nigerian biology students to be difficult to learn. The results showed that experimental group students outperformed the control on achievement on the perceived difficult topic of excretion (F=18.26; p

Toward Understanding the Relationship between the Learning Progression of Energy and Scientific Disciplines

Mihwa Park, Michigan State University
Xiufeng Liu, State University of New York At Buffalo (SUNY)
Joseph A. Johnson, Edinboro University of Pennsylvania

ABSTRACT:
The investigation of students' prior conceptions of energy has been conducted in numerous studies, yet directly comparing student understanding of energy in different science disciplines remains a challenge. The purpose of this study is to examine the students' understanding of the energy concept in different science disciplines in relation to science contents. In order to assess their understanding across different disciplines, InterDisciplinary Energy Assessment (IDEA) was used. The partial credit Rasch model was applied to the data to compute item and person measures. Results show that overall items of energy degradation/conservation are the most difficult, but average item difficulties of energy source/form and of energy transfer are not statistically different. The average difficulties of items by disciplines showed that there is no statistical difference. In addition, the four science disciplines are positively correlated in terms of understanding of the energy concept. When item difficulties of energy aspects were analyzed by disciplines or science contents, the sequence of item difficulties in energy aspects is not consistent across science disciplines or science contents. This result suggests that there is no universal order to difficulty in understanding of the energy aspects; item difficulties of energy aspects were compounded with specific science discipline contents.

Peer Support of Identity Exploration in a Conversation about STEM Choices

Dana Vedder-Weiss, Ben-Gurion University of the Negev and Tel-Aviv University, Israel
Avi Kaplan, Temple University

ABSTRACT:
Identity formation repeatedly arises in the literature addressing STEM career choice (e.g., Tan, Calabrese Barton, Kang and O'Neill, 2013). Yet, there is still much to understand about how identity processes frame students' choice to pursue STEM academic paths and how peers influence each other's identity related choices. In the current study, we investigated the mechanisms through which adolescents, who engage in a conversation, facilitate or hinder their peers' identity exploration around STEM educational choices. Analysis focused on

three 9th graders discussing their upcoming high-school track choices. It followed a framework for promoting identity exploration (Kaplan, Sinai & Flum, 2014) combined with an Interaction Process Analysis (Bales, 1950). Findings pointed to ways peers' promoted and constrained exploration by operating on exploration relevance, trigger, safety and scaffold. The findings of this study advance our understanding of the role peers may play in adolescents' identity exploration regarding STEM educational choices. They highlight the potential of peer conversations to support identity exploration and STEM decision making, underscoring their value within designed educational environments.

Promoting Productive Disciplinary Engagement in an Engineering Design Task
Chandan Dasgupta, University of Illinois at Chicago
Tom Moher, University of Illinois at Chicago
ABSTRACT:
There is a need for young learners to productively engage with engineering practices of design optimization, making tradeoffs, testing, revising and retesting. We present an approach using Improvable Design – sub-optimal designs representing inefficient or incomplete solutions to an engineering design challenge – as priming artifacts to engage learners with the task of designing a model of an optimal plumbing system for a house. We discuss a case of productive disciplinary engagement between two groups in a sixth grade classroom and highlight how our learning environment facilitated this engagement by problematizing content, giving learners authority, making them accountable and providing relevant resources to them. We found that learners were comparing designs, making tradeoffs between multiple design variables, doing mathematical calculations, verifying the reported values and rectifying errors. Students appropriated the Improvable Design and accompanying prompts in effective ways to understand the design limitations and construct abstract rules of thumb. They collaboratively came up with efficient strategies for identifying deficiencies in their solution using the rules and then worked towards optimizing their solution.This highlights the potential usefulness of Improvable Design and accompanying instructions in helping young learners engage with engineering practices and design optimal solutions.

Transforming the Typical: Relationships among High School Chemistry Students' Perceptions of a Constructivist Learning Environment, Prototype Match, and Science-Related Career Expectations
Andrew Wild, Stanford University
ABSTRACT:
Considerable attention has been devoted to factors affecting the persistence of women and historically underrepresented ethnic groups in their science education trajectories. The literature has focused more on structural factors that affect longitudinal outcomes rather than classroom experiences. This exploratory survey study examined relationships among high school chemistry students' perceptions of a constructivist learning environment (CLE), prototype match, and science-related career expectations. Prototype match was defined as the similarity between students' self-views and perceptions of best chemistry students. The sample included 702 students from 7 public high schools within the San Francisco Bay Area. Students' perceptions of a CLE predicted their expectations of entering a science career, but not engineering, computer, health, or mathematics-related careers. Moreover, best chemistry student prototype match partially mediated the relationship between perceptions of a CLE and science career expectations. When all groups of students perceived the learning environment as more constructivist, they were more likely to see themselves as similar to best chemistry students and expect science careers.

Strand 2: Science Learning: Contexts, Characteristics and Interactions
Related Paper Set - Discourse Practices across Science Education Contexts
2:45pm - 4:15pm, Grand A

Presider: Gregory J. Kelly, Penn State University
Discussant: Maria Varelas, University of Illinois at Chicago
ABSTRACT:
A focus on discourse practices is becoming increasingly prominent in the conceptualization of science learning and teaching, curriculum development, and teacher education. This session brings together a set of studies drawing from a common methodological orientation to the study of discourse across contexts. The examination of discourse practices across contexts has consequences for understanding teaching and learning science in schools and through teacher education. Each of the four studies examined a different substantive issue to identify how theoretically grounded studies of discourse contribute to the ongoing conversation about developing educational programming oriented to address the knowledge and practices of science in schools. The four substantive issues studied - students' identities, students' emotional response to ecological degradation, student and teacher learning to use evidence in a bilingual class, and teacher development of repertoires of reflective discourse about teaching - all represent ways that discourse practices have consequences in science education settings. Each of these four studies draws specific implications for research regarding the study of discourse and social practices.

Exploring Kindergarten Girls' Identities-In-Practice through Discourse
Alicia McDyre, Penn State University
Carla Zembal-Saul, Penn State University
Gregory J. Kelly, Penn State University
Maria Varelas, University of Illinois at Chicago

Arguing from Evidence in an English/Spanish Dual Language Middle School Science Classroom
Peter R. Licona, Penn State University
Gregory J. Kelly, Penn State University

Teacher Candidates' Meaning Making of Science Teaching in Secondary Teacher Education
Arzu Tanis Ozcelik, Penn State University
Scott McDonald, Pennsylvania State University

Studying Students' Emotional Response to Ecological Crises through Discourse
Elizabeth Hufnagel, University of Pittsburgh

Strand 4: Science Teaching--Middle and High School (Grades 5-12): Characteristics and Strategies
Scientific Inquiry and Science Literacy
2:45pm - 4:15pm, Columbus IJ
Presider: Xiang Chen, People's Education Press

Conceptualizing a Core Set of Secondary Science Teaching Practices for English Learners
Edward G. Lyon, Arizona State University
Sara E. Tolbert, University of Arizona
Jorge Solis, University of Texas at San Antonio
Trish L. Stoddart, University of California, Santa Cruz
George C. Bunch, University of California, Santa Cruz
ABSTRACT:
This presentation reports on the conceptual underpinnings of an observation rubric used to study how novice secondary science teachers teach science to English learners (or ELs). Drawing on theories of language-science

integration, we articulated four interrelated instructional practices known to promote both authentic science learning and English language and literacy development for ELs: Scientific Sense-making through Scientific and Engineering Practices, Scientific Discourse, English Language and Disciplinary-Literacy Development, and Contextualized Science Activity. We translated the conceptual underpinnings of each instructional practice into observable criteria across four levels of classroom implementation: ranging from limited/no implementation of the practice, to implementation that may supplant opportunities for authentic science learning and language development (introducing), to implementation that fully supports authentic science learning and language development (implementing/elaborating). Our presentation argues for this core set of practices as a productive Framework for studying how novice secondary science teachers are prepared to teach science to ELs. The presentation advances research on core science teaching practices to the specific context of teaching ELs in ways that (1) align with Next Generation Science Standards and Common Core State Standards and (2) emphasize the discipline-specific nature of EL supports.

An Investigation of Chinese Teachers' Inquiry-oriented Classroom Discourse
Hui Jin, Ohio State University
Xin Wei, Physics Editorial Department, People's Education press
Qiancheng Peng, Physics Editorial Department, People's Education press
Hayat Hokayem, Texas Christian University
ABSTRACT:
We investigate how classroom discourse supports meaningful learning in teacher-designed inquiry lessons. Our data sources are 12 lesson videos that to certain degree represent the best teaching practice of physics teachers at three different stages of their professional career. Our research question is: How do pre-service teachers, experienced teachers, and expert teachers compare in structuring inquiry-oriented classroom discourse? We developed a three-dimensional framework (i.e., cognitive processes, disciplinary reasoning, and talking science) to examine teachers' classroom discourses. The results suggest although teachers in general demonstrated good practice in using classroom discourse to support inquiry-based learning, none of the teachers talked with students about dealing with anomalous data, which is an important cognitive process that had led to conceptual change in the history of science. In addition, none of the experienced and pre-service teachers discussed with their students about the reasoning beneath intuitive ideas.

How Literacy Integration Contributes to the Understanding of Scientific Practices through Reading Combined Text Genres
Mesa B. Davis, Georgia State University
Abdulkadir Demir, Georgia State University
ABSTRACT:
This preliminary investigation examined how a teacher used the reading of combined text genres (the traditional science textbook, popular science articles, and Adapted Primary Literature [APL]) to influence the understanding of scientific practices in a science classroom. The participants were a sixth grade science teacher and ten students at an academically rigorous independent school in the southeastern United States. The collection of primary data consisted of the observation of thirteen 45-minute lessons during which the readers focused on the text and the teacher performed constant, metacognitive assessments of the classroom environment with the goal of adjusting instructional strategies to suit the specific needs of the students. Interviews, questionnaires, and the collection of artifacts such as lesson plans and worksheets served as secondary data collection methods. The data was analyzed and coded using dialogic/performance analysis techniques. The following themes emerged from the data: the identification of the components of experimental design, the application of scientific knowledge to real world situations, and the elicitation of evidence to support scientific conclusions. A narrative chronicling how the teacher used reading combined text genres to influence the understanding of scientific practices was constructed.

Building Students' Written Scientific Explanations through Explicit Disciplinary Literacy Instruction

Gde Buana S. Putra, National Institute of Education
Kok-Sing Tang, National Institute of Education

ABSTRACT:
Scientific explanation is a genre that is central to the learning of science. Writing scientific explanation is one of the key skills required in the discipline. This paper reports on a finding from a design-based research with a purpose to help secondary school chemistry students develop an important literacy skill in science – the writing of scientific explanations. A series of lessons on the topic of Chemical Bonding was designed to explicitly teach the three-part structure often found in the genre of scientific explanation and provide opportunities for students to apply the structure. The lesson series was observed and students' worksheets and test papers were collected and analyzed. The analysis of the structure of students' written scientific explanation was done through genre analysis. Most students were found to be able to write well-structured scientific explanations addressing the topic of Chemical Bonding but only a fraction of them could re-contextualize their knowledge of a scientific explanation genre to other topics. From the findings, the strengths and limitation of disciplinary literacy instruction in building students' scientific explanation writing skill will be further discussed.

Strand 5: College Science Teaching and Learning (Grades 13-20)
Engineering Teams and Problem-Solving
2:45pm - 4:15pm, Grand D North
Presider: Senay Purzer, Purdue University

The Role of Question, Conflict, and Reasoning Episodes on Engineering Team Performance

Muhsin Menekse, University of Pittsburgh
Senay Purzer, Purdue University
Douglas D. Stouch, University of Pittsburgh
Felicia R. Bixler, University of Pittsburgh

ABSTRACT:
Decision-making, especially in team settings, is a critical but challenging skill. Discourse within groups can influence decision quality and learning outcomes. To investigate the relationship between individual contributions to discourse and team performance, this study explored the role of individual and team level factors as predictors of learning outcomes in an engineering design domain. Audio and video data of engineering student teams have been coded for question, conflict, and reasoning episodes to explore the connection between team dynamics, quality of collaboration, and individual learning outcomes. These data were analyzed using a quantitative discourse analysis approach. We found an inverse relationship between reasoning episodes and all other variables including team-learning outcomes. This finding also suggests that engaging more on conflict and question type episodes rather than reasoning may foster learning outcomes.

Using Discourse Analysis and Self-Reflection to Improve Undergraduate Engineering Team Experiences

Aditi Joshi, Olin College of Engineering
Allison Tau, Cooper Union for the Advancement of Science and Art
Yevgeniya V. Zastavker, Olin College of Engineering
Veronica Darer, Wellesley College

ABSTRACT:
Though in recent years, teamwork has become a "go to" pedagogical strategy in many undergraduate STEM programs, there are few studies on the role of group/partner work in college STEM classrooms. Discourse analysis is a research method that is currently underutilized, but can help to gain a deeper understanding of

individual team member's interactions and their effect on hindering or improving overall team context. Used as a reflective tool, discourse analysis provides a way for students to understand the explicit and implicit culture they create as they interact. Instructors can use discourse analysis to comprehend each team's ethos revealed by the quality and quantity of students' participation patterns. This paper seeks to uncover the unique cultures established in six co-ed teams of first-year engineering students in a design course and in one senior design project team. We investigate two research questions: (1) What discursive successes and challenges do students face in their teams? and (2) How do successes and challenges uncovered through discourse analysis compared with students' reflections about their teaming experiences? We describe our findings and discuss implications for guiding and supporting team activities with these techniques.

Relationships between Engineering Students' Future Time Perspectives and Their Problem Solving Processes

Catherine D. McGough, Clemson University
Adam Kirn, University of Nevada, Reno
Lisa C. Benson, Clemson University

ABSTRACT:

The purpose of this directed content analysis was to describe the relationship between students' future time perspectives (FTP) and knowledge transfer during an open-ended engineering problem for second year engineering students to answer the research question: how do engineering students' FTP relate to their knowledge transfer during an engineering problem? The results show that students who view engineering problems as open-ended tend to approach the problem conceptually and show a deeper understanding of the problem. Students with well-defined futures display the metacognitive strategies that instructors encourage: well-defined planning stages, and frequent monitoring. This study strongly encourages the value of understanding student motivations to achieve more personalized and effective instruction.

Strand 7: Pre-service Science Teacher Education

Symposium - Handbook on Research in Science Education: Implications for Preservice Science Teacher Education

2:45pm - 4:15pm, Columbus AB

Presider:

Norman G. Lederman, Illinois Institute of Technology

ABSTRACT:

Preservice Education, Strand 7, Sponsored Session The focus of this session will be on the chapters of the newly released Handbook on Research in Science Education (Volume II) related to preservice teacher education. In particular authors will address the specific implications of their chapters to preservice science teacher education. There will be six roundtables with authors from two chapters at each table. Each table will have chapters that have some common links. There will be a 10 minute overview of the Handbook and then session participants will cycle through four tables of their choice, changing tables every 20 minutes. Authors will briefly summarize the most important findings in their chapters focusing specifically on preservice teacher education.

Student Conceptions and Conceptual Change: Three Overlapping Phases of Research

Tamer G. Amin, American University of Beirut
Carol L. Smith, University of Massachusetts-Boston
Marianne Wiser, Clark University

Learning Science Outside of School

Leonie J. Rennie, Curtin University of Technology

Gender Matters: Building on the Past, Recognizing the Present, and Looking Toward the Future
Kathryn Scantlebury, University of Delaware

English Learners in Science Education
Cory A. Buxton, University of Georgia
Okhee Lee, New York University

Special Needs and Talents in Science Learning
J. Randy McGinnis, University of Maryland
Sami Kahn, University of South Florida

Culturally Responsive Science Education for Indigenous and Ethnic Minority Students
Elizabeth McKinley, University of Aukland
Mark J. S. Gan, University of Aukland

Discourse Practices in Science Learning and Teaching
Gregory J. Kelly, Pennsylvania State University

Promises and Challenges of Using Learning Technologies to Promote Student Learning of Science
Joseph S. Krajcik, Michigan State University
Kongju Mun, Michigan State University

Scientific Practices and Inquiry in the Science Classroom
Jonathan Osborne, Stanford University

Research on Teaching and Learning of Nature of Science
Norman G. Lederman, Illinois Institute of Technology
Judith S. Lederman, Illinois Institute of Technology

Precollege Engineering Education
Christine M. Cunningham, Museum of Science, Boston
William S. Carlsen, Pennsylvania State University

Science Teacher Attitudes and Beliefs: Reforming Practice
M. Gail Jones, North Carolina State University
Megan Leagon, North Carolina State University

Strand 7: Pre-service Science Teacher Education
Inquiry, Epistemic Beliefs, and Argumentation
2:45pm - 4:15pm, Water Tower
Presider: Rosemary Russ, University of Wisconsin

An Adaptation Study of the Epistemic Beliefs Inventory with Turkish Pre-service Science Teachers
Busra Tuncay-Yüksel, Giresun University
Ozgul Yilmaz-Tuzun, Middle East Technical University
Dana L. Zeidler, University of South Florida

ABSTRACT:
One of the main purposes of the present study was to contribute to the epistemological beliefs literature by adapting and validating Epistemic Beliefs Inventory (EBI) to be used in Turkish contexts, which would enable examining cross-cultural validity of the instrument and universal and culture-specific aspects of epistemological beliefs measured by it. Adaptation of the instrument was realized through two successive studies in which Turkish pre-service science teachers were selected as the participants (N= 218 for Study 1, N=1523 for Study 2). Factor analysis of data clearly showed multidimensional nature of epistemological beliefs. Moreover, adapted version of the instrument successfully captured all of the five epistemological belief dimensions (i.e., simple knowledge, certain knowledge, omniscient authority, innate ability, and quick learning) proposed by multidimensional epistemological beliefs model. Findings obtained throughout the adaptation of the instrument provided important insights with regard to factor structure of epistemological beliefs and research conducted in this field. Similarly, descriptive analyses of the pre-service science teachers' responses revealed some valuable implications regarding the influences of cultural and educational contexts for epistemological beliefs. Nevertheless, further research is necessary to confirm reliability and validity of the instrument and make more robust interpretations.

Supporting Responsive Teaching Practices through Pedagogical Argumentation
Rosemary Russ, University of Wisconsin
Leema Berland, University of Wisconsin
Melissa Braaten, University of Wisconsin
ABSTRACT:
In the past decade, science education has rallied around the assumption that meaningful science learning must involve teachers listening and responding to their students' ideas in the classroom—that teachers must engage in responsive teaching practices. Research has shown that, while teaching of this sort is extremely difficult, it is something pre-service teachers (PSTs) can do in supportive contexts. Despite recent efforts, precisely how we encourage consistent PST attention to student ideas remains largely craft knowledge within the field. We propose a new discourse practice—pedagogical argumentation—in order to help reify the field's craft knowledge into a systematic practice for supporting teachers in responsive teaching. In pedagogical argumentation, PSTs identify, interpret, and argue with and about students' science ideas in the service of making pedagogical decisions. In this paper, we present theoretical principles guiding the support of pedagogical argumentation and empirical investigations of whether and how PSTs engage in the complex reasoning necessary to engage in the responsive teaching practices of noticing, interpreting, and responding to student ideas.

Practical Considerations: Elementary Preservice Teachers' Uses of Principle-based Inquiry in Planning and Teaching Science
Martha M. Canipe, University of Arizona
Kristin L. Gunckel, University of Arizona
ABSTRACT:
A persistent challenge in preparing elementary preservice teachers to teach inquiry science is convincing preservice teachers that principle-based approaches to teaching science are useful for addressing practical problems that teachers face in elementary classrooms. To understand this situation better, we explored when, how, and why three preservice elementary teachers used the principle of placing experiences before explanations during instruction when planning and teaching science in their elementary classrooms. We videorecorded preservice teachers teaching a science lesson and interviewed them about their teaching decisions. Using practicality theory as a lens, we examined preservice teachers decisions about whether the principle helped them address the practical problems of teaching that they encountered as preservice teachers. We found that for these preservice teachers, the practicality of putting experiences before explanations when

teaching science was influenced by the ways in which the preservice teachers perceived their obligations to their mentor teachers. While teacher educators have long recognized the influence of mentor teachers in preservice teachers' enactments of principles from science methods courses, our analysis provides some understanding of the reasons for how and why this phenomenon occurs.

Strand 7: Pre-service Science Teacher Education
Preservice Teachers' Views about the Nature of Science and Scientific Inquiry
2:45pm - 4:15pm, Grand Suite 3
Presider: Robert H. Evans, University of Copenhagen

Developing Pre-Service Science Teachers' NOS Views: Using Blogs as A Platform for Reflection
Sinan Ozgelen, Mersin University
Hatice Sancar Tokmak, Mersin University
Lutfi Incikabi, Kastamonu University
ABSTRACT:
The purpose of this study was to investigate pre-service science teachers' (PSTs) perceptions about their nature of science (NOS) views after attending History and Nature of Science course offered with the support of blogs as a platform for reflection. Totally, 70 PSTs (44 female, 26 male) accepted participating to the study as voluntarily. The class was held 3 hours a week. The course provided meaningful and practical reflection-based experiences, as well as explicit and reflective instruction to help pre-service science teachers' gain a deeper understanding of NOS. The study was qualitative in nature, and the data collected through questionnaire, interviews, and students' posting messages and comments on Nature of Science Course blog. This study was concerned with the development of PSTs' understanding of NOS and specifically their ability to reflect their views using blogs. After the analysis whole data, results showed that PSTs developed their NOS views. In addition, PSTs indicated that they found blogs a beneficial educational tool for reflecting their ideas. The study showed that using blogs as a platform for reflection provided opportunities for PSTs to discuss NOS views on blogs, compare their opinions with friends, and check their opinions after discussions.

Preservice Special Education Teachers' Views on Scientific Inquiry
Rajlakshmi Ghosh, Kent State University
Lisa A. Borgerding, Kent State University
ABSTRACT:
This qualitative study explored views on scientific inquiry as held by sixteen K-8 preservice special education (SPED) teachers selected from a science methods course. The study focused on identifying the studied preservice SPED teachers' views on their inquiry teaching and learning experiences. Data was collected from interviews, microteaching videos, lesson plans, reflection papers, exam papers and course completion questionnaires and analyzed using a grounded theory approach. It was found that studied prospective SPED teachers viewed scientific inquiry as a useful pedagogical tool that was beneficial to all students, including students with special needs. Participants expressed that inquiry was transcendental, and that it could be adapted in both inclusive classrooms and SPED resource room to fit the needs of SPED students. Implications towards teacher education of both general science teachers and SPED teachers are discussed.

An Analysis of Preservice Elementary Teachers' Understanding of Inquiry-based Science Learning and Teaching
Carole K. Lee, University of Maine at Farmington
Marilyn Shea, University of Maine at Farmington
ABSTRACT:

This study examines how preservice elementary teachers (PSETs) view inquiry-based science learning and teaching, and how the science methods course builds their confidence to teach inquiry science. Most PSETs have a general view that inquiry is just asking students questions rather than a formal set of pedagogical tools. In the present study, three groups of PSETs (n = 14, 20, 20) were included. For each group, pretest and post-test attitudes and knowledge base were assessed using a 32 item questionnaire combining twenty-six Likert-type and six open-ended questions as well as half-hour semi-structured one-on-one interviews. Results from the pretest questionnaires showed that most PSETs had simplistic views of inquiry-based teaching. The researcher was able to modify the science methods course (the intervention phase) to focus on the concepts of science-based inquiry teaching that were shown to be lacking in the PSETs' knowledge base. The analysis of the post-test questionnaire showed significant increase on 17 of the 26 Likert-type questions reflecting increases in PSETs' understanding of inquiry-based teaching. More importantly, the confidence expressed by PSETs in their ability to teach science using inquiry methods increased at the end of the semester.

Changing Preservice Science Teachers' Views of NOS: Why Some Conceptions May be More Easily Altered

Gunkut Mesci, Western Michigan University
Renee S. Schwartz, Georgia State University

ABSTRACT:
The purpose of this study is to assess pre-service teachers’ views of Nature of Science (NOS) and any changes in these views after explicit/reflective NOS instruction. This study particularly focuses on why and how some aspects of NOS may be more easily altered than others. Fourteen pre-service science teachers enrolled in a NOS course participated in this study. Data were collected by using a pre/post format with the VNOS-270, VOSI-270, follow-up interviews, and classroom artifacts. The results indicate that most students initially held naïve views about certain aspects of NOS like tentativeness and subjectivity.Only a few students held informed views about some aspects of NOS. By the end of the semester, most students improved their understanding about almost all aspects of NOS. Only a few students still struggled with certain aspects like the difference between scientific theory and law, tentativeness, and socio-cultural embeddedness. Students think that classroom activities, discussions, and readings were most helpful to improve their views about NOS. Results suggest that instructional, motivational and socio-cultural factors may influence if and how they change their views about some NOS aspects. The findings from this study have potential in translating research insights into practical advice for teachers and science educators.

Strand 7: Pre-service Science Teacher Education
Teachers' PCK and Understandings of Science Teaching
2:45pm - 4:15pm, Columbus EF
Presider: Julie M. Kittleson, University of Georgia

The Relationship between Preservice Teacher Self-regulation and PCK

Aysegul Tarkin, Yuzuncu Yil University
Esen Uzuntiryaki-Kondakci, Middle East Technical University
Fatma Nur Akin, College of Education, Middle East Technical University
Betul Demirdogen, Bulent Ecevit University
Sevgi Aydin, Yuzuncu Yil University

ABSTRACT:
This study investigated the interaction between preservice teachers’ pedagogical content knowledge (PCK) and their self-regulation for teaching. Participants were five of fifteen preservice chemistry teachers, information rich cases and volunteers (four females and one male), enrolled to the practicum course. Data were collected via content representation (CoRe) and semi-structured interviews. Data were analyzed through deductive analysis

by the use of existing categories and content analysis for identification of a particular interaction between teacher self-regulation and PCK. The connection between self-regulatory processes and PCK was most frequent in forethought phase, moderate in self-reflection phase, and least in performance control phase. Knowledge of instructional strategies (KoIS) was the PCK component that preservice teachers brought into play mostly in all three phases of self-regulation. This study revealed that there were limited connections between PCK components and teaching self-regulatory processes. Implications for science teacher education and research are discussed.

Using Practice-based Pedagogy to Support Elementary Teacher Candidates' Understandings of Science Teaching

Julie M. Kittleson, University of Georgia
Janna Dresden, University of Georgia
Laura B. Schneider, University of Georgia
Julianne A. Wenner, University of Connecticut

ABSTRACT:
Elementary teachers should implement instruction that supports young students' science learning. Teacher educators, therefore, are responsible for preparing teacher candidates (TCs) to implement instruction that supports young students' science learning. One challenge involves motivating TCs to understand that the science content included in elementary curriculum is not unproblematic. That is, teaching seemingly simple concepts can be complex. Further, teacher educators should help TCs understand how to balance the stability and flexibility associated with teaching. We designed a model based on tenets of practice-based pedagogy to support TCs understandings of how to teach science. These tenets were operationalized by designing an innovative strategy that included working with small groups of students, teaching the same lesson multiple times, rotating roles, using model lessons, and engaging in structured reflection. After participating in this model, TCs recognized that (1) seemingly simple science concepts can be difficult to teach and (2) investing in planning provided structure and flexibility that helped TCs elicit students' ideas and modify instruction in response to students' ideas. These findings provide support for using tenets of practice-based pedagogy as a way to support prospective teachers' understandings of science teaching.

The Impact of Socialization on Beginning Science Teachers' Pedagogical Decision Making and Science Instruction

Lori M. Ihrig, University of Iowa
Joanne K. Olson, Iowa State University
Michael P. Clough, Iowa State University

ABSTRACT:
Induction and mentoring programs are promoted to support beginning teachers, improve teacher effectiveness, and reduce attrition. We conducted a three-year qualitative multiple-case study following ten graduates from a research-based secondary science teacher education program (TEP) during their TEP and first two years of teaching to examine their pedagogical decision-making, teaching practices, and socialization experiences. The findings support the contention that beginning science teachers effectively educated to make research-based science instruction (RBSI) decisions and implement such practices will do so—if they are supported through collegial relationships with cohort members and advocacy from superordinates. Equally important, teachers leaving their TEP with little understanding of RBSI are unlikely to develop such understanding and implement such practices during their first two years of teaching. Contrary to the commonsense view that experienced teachers and administrators will be effective more-knowledgeable RBSI mentors, the beginning science teachers in this study encountered superordinates who threatened, sabotaged, and imposed sanctions in response to participants' attempts to implement practices congruent with RBSI. At best, four participants encountered advocates during their second year of teaching because they selected new school districts or experienced new

administration. This study has important implications for beginning science teachers, teacher education programs, mentoring programs, and administrators.

Prospective Science Teachers' PCK Development through Reformed Modern Physics Course at a College of Education

Jungsook Yoo, Ewha Womans University
Kevin Insik Hahn, Ewha Womans University

ABSTRACT:
This study aimed to develop prospective science teachers' PCK through reforming a modern physics course at a college of education. This study adopted the Interconnected Model for Teacher Professional Growth (IMTPG model) (Clarke & Hollingsworth, 2002) as a basic theoretical framework and modified a modern physics course at university for prospective teachers' professional development when teaching modern physics. The IMTPG model explained the mechanism that identified the nature of an individual teachers' professional development. The modified modern physics course was included stimulated reflective practices to improve prospective teachers' PCK as well as SMK. The reformed modern physics course provided reflective practices with supports to the prospective teachers for the development of PCK which were needed for teacher professional development. This study follows a class of prospective teachers through a modern physics course. The guiding research questions include followings: Is the reformed science course effective in what the prospective teachers' PCK development? How does PCK develop in a group, and what type of characteristics are found in the developmental process for PCK?

Strand 8: In-service Science Teacher Education

Symposium - Supporting Teachers in Teaching Scientific Practices: Designing In-person and Digital Learning Environments for Teachers

2:45pm - 4:15pm, Columbus CD

Presider: Katherine L. Mcneill, Boston College
Presenters:
Suzanna Loper, Lawrence Hall of Science
Jonathan Francis Osborne, Stanford University
Eric Berson, Stanford University
Brian J. Reiser, Northwestern University
Jean Moon, Tidemark Institute
Sarah Michaels, Clark University
Cynthia Passmore, University of California-Davis
Arash Jamshidi, University of California, Davis
Laura Shafer, University of California, Davis

ABSTRACT:
Recent reform documents and standards advocate for a new vision of proficiency in science, which highlights the importance of scientific practices. Currently, k-12 science instruction fails to meet this vision in part because of a focus on discrete science facts and a lack of opportunities for students to experience science. The teacher is essential for implementing this new focus on scientific practices in ways that make learning accessible to all students. However, teachers can lack the depth of knowledge needed to integrate scientific practices into classroom instruction. Consequently, it is essential for teachers to receive sufficient support to develop an understanding of scientific practices and appropriate instructional strategies to create supportive learning environments. During this symposium, we will explore how to design learning environments that support teachers in developing a rich understanding of scientific practices that can inform their own classroom instruction. Four projects will present their current work addressing this problem utilizing different learning

environments including a focus on multimedia educative curriculum materials, online study groups, in-person professional development and in-person study and action group. Our goal is to synthesize trends, issues and future directions across the projects, which should be considered by the field in supporting teachers.

Strand 8: In-service Science Teacher Education
Supporting Teachers for Inquiry Practice
2:45pm - 4:15pm, Grand Suite 5
Presider: Dorene R. Medlin, Albany State University

Impact of a Summer Institute and Instructional Coaching on Tecaher and Student Science Inquiry Practice
Gwen Nugent, University of Nebraska
Gina Kunz, University of Nebraska
Jon E. Pedersen, University of Nebraska-Lincoln
James A. Houston, University of Nebraska-Lincoln
Soonchun Lee, Wichita State University
LinLin Luo, University of Nebraska-Lincoln
Irina Kalutskaya, University of Nebraska-Lincoln
Brandi Berry, University of Nebraska-Lincoln
ChaoRong Wu, University of Nebraska-Lincoln
ABSTRACT:
This randomized controlled trial with 119 middle and high school science teachers investigated the effects of professional development involving a summer institute and follow-up instructional coaching focusing on guided scientific inquiry. Treatment teachers participated in a two-week summer institute employing evidence-based professional development practices of modeling, practice, and feedback followed by technology-delivered instructional coaching sessions led by project-based science coaches over 6–8 weeks during the following school year. The coaching process focused on teacher-coach planning followed by opportunities for teachers to practice, refine, and analyze new and existing skills. The control group represented “business as usual” (i.e., access only to typical science PD). Results showed that the combination of a face-to-face summer institute and follow-up coaching was an effective strategy to positive impact teacher and student practice of inquiry. Participation in the summer institute resulted in higher teacher inquiry knowledge, self-efficacy and practice when compared to a control. The coaching led to continued increases in self-efficacy and more effective inquiry classroom practice as measured through three separate observation instruments. Comparisons of students from treatment and control teachers also showed significantly higher inquiry performance for the treatment group.

Coaching for Sustainability: Distance-Based Peer Coaching Science Inquiry
Soonchun Lee, Wichita State University
Gwen Nugent, University of Nebraska
Gina Kunz, University of Nebraska
James A. Houston, University of Nebraska-Lincoln
ABSTRACT:
To improve teachers' capacity in teaching science, professional development (PD) is required to successfully integrate inquiry knowledge and skills into effective classroom practices. However, results from recent national science teacher surveys showed that teacher inquiry knowledge and use of inquiry teaching strategies is lacking in classrooms. The present study has provided a PD with distance-based peer coaching for teaching science as inquiry to 16 teachers in rural schools. The results showed that the teachers' science inquiry knowledge, confidence in inquiry instruction, self-efficacy for inquiry instruction, and confidence in peer-coaching improved significantly after the summer institute and was maintained throughout the school year. The teachers'

improved inquiry knowledge and confidence were followed by continuing implementation of guided-inquiry instruction throughout the second school year, forming science teacher community with sense of belonging in rural schools, equipping systematic self-reflective practice on their teaching and student learning, and improving their students' inquiry knowledge and science achievement. This present study demonstrated the value-added benefits of distance-based peer-coaching in a PD for teachers when schools are located in rural and remote areas. In addition, this distance peer-coaching model can also be replicated for pre-service STEM teacher education with videotaped teaching practice and web-based conferencing technologies.

Teaching Reform-Based Science as Argument: Use by Veteran Supervising Teachers
Kathy Peno, University of Rhode Island
Elaine Silva Mangiante, University of Rhode Island
ABSTRACT:
This qualitative study examined the reform-based science teaching practices of veteran elementary teachers who (1) served as supervising teachers of pre-service teachers, (2) received extensive professional development in reform-based science, and (3) had access to commercially developed science kit materials in order to determine their understanding and use of teaching science as argument based on Zembal-Saul's (2009) continuum for teaching science as argument. From individual case and cross-case analyses, the findings suggested that the nature of the science instruction and the conceptualization of science teaching by veteran teachers did not include science as argumentation, except for a teacher with extensive content knowledge and professional development in reform-based science. Through document analysis of the science kit teachers' guides and training manuals used for two of the professional development programs attended by the teachers, the evidence indicated that there was no reference to argumentation in the teachers' directions. These results suggest that teachers do not have access to models or scaffolding in strategies to teach science as argument. The implications are that if pre-service teachers are to be supported in acquiring skill in science pedagogy as argumentation, supervising teachers will need argument-based resources and professional development to acquire these skills themselves.

Inquiry Instructional Practice in Middle School Science Classes: Applying Vroom's VIE Theory of Motivation
Daniel M. Alston, Clemson University
Jeff C. Marshall, Clemson University
ABSTRACT:
While inquiry-based instruction is seen to have the potential to increase student achievement, teachers do not always value this type of instruction, nor do they always have high self-efficacy for engaging students in this type of instruction. Teacher beliefs about certain practices (expectancies), their value of certain outcomes, and their belief that certain practices can lead to valued outcomes (instrumentality) is among the reasons why teachers choose to use inquiry-based instruction. It is often claimed that professional development programs can be a driving force to change teachers' positions on these constructs thus motivating teachers to choose to reform their instruction. The aim of this mixed methods study was to determine: 1) If Vroom's VIE theory of motivation could provide insight into why teachers choose to implement inquiry-based instruction in their classroom and 2) If there was a relationship between teacher knowledge of inquiry instruction and their inquiry-based practices. The findings from this study suggest that teachers' expectancies are positively related to their practice and that knowledge may be a factor that contributes to this relationship. Implications and recommendations for educational researchers and designers of professional development are provided.

Strand 8: In-service Science Teacher Education
Teachers' Epistemic Beliefs and Views of Nature of Science
2:45pm - 4:15pm, Randolph

Presider: Barbara A. Crawford, The University of Georgia

Assessing Teachers' Competencies in Teaching Nature of Scientific Knowledge Through Educational Critical Scenarios

Cigdem Han Tosunoglu, Marmara University
Serhat Irez, Marmara University
Nihal Dogan, Abant Izzet Baysal University
Yalcin Yalaki, Hacettepe University
Gultekin Cakmakci, Hacettepe University
Eda Erdas, Kastamonu University
Zekai Berk Altiner

ABSTRACT:
The purpose of this study assesses the competence of a group of science teachers in identifying NOSK themes in scenarios on various socio-scientific issues. Utilizing socio-scientific issues has become an important means in communicating NOSK in school science. It is considered that inclusion of SSI in school science could provide important opportunities to address students' understanding of scientific enterprise and develop higher order thinking skills in decision making process. Participants of this study were 15 science teachers that had attended a large-scale teacher professional development project (PDP) aimed at improving science teachers' views of NOSK. Data was collected through interviews and an open-ended questionnaire after PDP. The participants' understandings of NOSK were assessed through VNOS-C. Teachers' ability to identify NOSK issues in SSI was assessed through an open-ended questionnaire. The questionnaire featured 5 educational critical scenarios (ECS) titled "Dinosaurs", "Global warming", "Cholesterol", "Ozone layer" and, "Classification". These scenarios were used to assess teachers' competence to identify relevant NOSK aspects. The findings of the study revealed that the participant teachers' developed informed views about the aspects of NOSK in consideration as a result of the professional development program. However, the participants failed to transfer this knowledge and could not exhibited similar competence in identifying aspects of science to be discussed and emphasized in ECSs.

Investigation of the Link between Continuing Professional Development (CPD) Programs and Students' NOS Views

Ferah Ozer, Abant Izzet Baysal University
Nihal Dogan, Abant Izzet Baysal University
Yalcin Yalaki, Hacettepe University
Serhat Irez, Marmara University
Gultekin Cakmakci, Hacettepe University

ABSTRACT:
The aim of continuing professional development (CPD) programs is to improve teachers' content knowledge, PCK and effectiveness of their classroom practices. Moreover, the aim of CPD programs about NOS is to support teachers in integrating the content and NOS tenets into classroom practices. Literature suggests that the studies generally focus on the achievement and efficiency of teachers following such CPD programs. However, the studies about the attained PCK and its reflection on classroom practices and the impact of CPD programs on indirect beneficiaries, namely students, are limited. Therefore, the purpose of this study is to survey the changes of 5th, 6th and 7th grade students' views of NOS by providing a large scale CPD program to their teachers. In this study, 10 (4 female, 6 male) science teachers' and 613 students' data and the changes in their views were analyzed. Results showed that the students' NOS views changed positively at the end of the CPD program; however, the differences have been reported among the grades of the students. For the impact of teachers on the students' view, the results also showed that, when the teachers' views on NOS changed positively, the students' view might change positively, accordingly.

Structural, Epistemic and Conceptual Aspects of Science Teachers' Argumentation in the Context of Biological Evolution

Ezgi Yesilyurt, Middle East Technical University
Jale Cakiroglu, Middle East Technical University
Ceren Oztekin, Middle East Technical University

ABSTRACT:
The present study investigates in-service elementary science teachers' argumentation practices in terms of conceptual, structural and epistemic aspects as well as how they articulate conceptual knowledge and argumentation practices at different epistemic levels across four scenarios regarding evolutionary theory. Data were collected through interview protocol regarding scenarios to inform this study. During interview sessions, science teachers were asked to construct arguments with respect to evolutionary phenomena provided in each scenario. For the purpose of either predicting similar findings (a literal replication) or contrasting findings (a theoretical replication), cross-case analysis was employed based on the case studies of individual participants. The cases were four science teachers in this study. The findings indicated that three teachers held misconceptions and cognitive biases regarding evolutionary theory. Four teachers did not generate sophisticated arguments even if conceptual understanding levels were relatively high. Besides, they struggle to coordinate theoretical claims with evidences. This may be related to unfamiliarity with the use of evidences. In addition, they brought their key concepts and also, misconceptions and cognitive biases to their justifications and oppositions.

Interaction of Teacher Understanding and Misconceptions Regarding Scientific Inquiry and Nature of Science

Yue Li, Miami University
Kyle Cox, Mason City Schools
Sarah B. Woodruff, Miami University

ABSTRACT:
This paper reports findings from a National Science Foundation funded Mathematics Science Partnership project that focuses on strengthening in-service teacher professional development (PD) during the critical transition from middle to high school. This paper examines the validity and reliability of teacher questionnaire regarding SI and NOS through factor analysis, Rasch analysis, and reliability tests and discusses the measurement issues that emerge when teachers' understanding and misconceptions of SI/NOS co-exist. If valid factors can be established for the lower performing subscales (i.e., SI and NOS), evaluators and researchers can further study how teachers' progressive acquisition of understanding of the Nature of Science and classroom inquiry interact with teachers' misconceptions regarding scientific inquiry and Nature of Science, as components of the teachers' belief system regarding science teaching and learning.

Exploring a Science Teacher's Epistemic Belief System and Socioscientific Discourse: The Relationships and the Barriers

Arzu Sonmez, Abant Izzet Baysal University
Ahmet Kilinc, Abant Izzet Baysal University

ABSTRACT:
The scholars consider that science teachers' core pedagogical beliefs and expectations of recent reforms based on socioscientific issues should be consistent to reach promising learning outcomes. Epistemological beliefs are one of these core beliefs. In addition, the reform makers expect science teachers to use discourse activities contextualized within SSI. On this point, we investigate the relationships between these two important variables – epistemologies and organization of SSI discourse – in the present study. In this investigation, we purposefully selected a science teacher (Sevil) due to unexpected incongruities between her epistemologies and SSI discourse. We uncover her epistemologies using semi-structured interviews based on a belief system approach.

In this approach, we asked questions about domain-general (beliefs about nature of knowledge) and domain-specific epistemologies (i.e. beliefs about nature of scientific knowledge). In addition, we used classroom observations of the SSI course organized by Sevil. In the data analyses of this single case study, we benefited from a range of categorizations suggested by the scholars. The results showed that Sevil's epistemic belief system included some congruities between domain-general and domain-specific epistemologies. However, her sophisticated epistemic system did not translate into her SSI discourse due to several barriers: philosophy of national education, old cultural norms, students' developmental deficiencies and personal stance. At the end of the paper, we suggested certain implications to remove such barriers.

Strand 11: Cultural, Social, and Gender Issues
Related Paper Set - Examining University Engineering Equity Efforts to Engage Underrepresented Learners
2:45pm - 4:15pm, Grand B
Presider: Noemi Waight, SUNY-UB
Discussant: Randy Yerrick, SUNY- UB
ABSTRACT:
Engineers are now entering the arena of informing policy, writing curricula, and even being funded for major professional development initiatives under the new definitions of STEM and in light of NGSS and Common Core. However, few engineers read science education research and even fewer inform their educational practices based upon a solid understanding of issues of equity and diversity. In fact, there is very few rewards in place to prompt engineers to regularly view STEM Teaching, Learning, and Research outside of their own personal and historical perspective. Given the well-documented tradition of elitism, privilege, and homogeneity among engineers and scientists, considering expert practice from such a limited view as this is very problematic for expanding membership for underrepresented groups of STEM. This group of engineers met regularly in a study group to read contemporary science education equity research, attempted culturally responsive teaching (as defined by Geneva Gay), and closely examined their individual and institutional responses attempting to address critical barriers to STEM programs, content, and careers. This paper set reflects the diversity of research, policy, and practice perspectives they chose to examine at multiple universities.

Celebrating Seventeen Years of Success—Or Was It?: Looking More Deeply and Closely at Measures of Success
Nelson Rivera, SUNY-UB
Ming Chiu, Purdue
Randy K. Yerrick, SUNY- UB
Steven Ciccarelli, RIT
Michael Parthum, RIT
William Leonard, RIT
Noemi Waight, University at Buffalo

Redefining Innovative Teaching: A Case Study of Shifting Pedagogical and Sociocultural Understandings of STEM Instruction and Requisite Knowledge among Engineers
Daniel Johnson, RIT
Michael Slivka, RIT
Monica Ridgeway, SUNY-UB
Jeanne Christman, RIT
Bhawna Chowdhary, SUNY-UB
Tiffany Nychae, SUNY-UB

STEM, Who's it for?": Partnerships, Dropouts, and Identity Throughout the Formation of STEM Programs for Marginalized Urban Youth
Monica Ridgeway, SUNY-UB
Tiffany Nyachae, SUNY-UB
Randy K. Yerrick, SUNY- UB
Fenice Boyd, SUNY-UB
Megan Whelan, University at Buffalo

Filling the STEM Pipeline: Factors Influencing College Major Selection in the City Scholars Program
Michael Eastman, RIT
Jeanne Christman, RIT
George Zion, RIT
Randy K. Yerrick, SUNY- UB
Noemi Waight, SUNY-UB

Latina and Black Female Engagement in STEM and Health Career Opportunity Programs
Megan Whelan, SUNY-UB
Randy K. Yerrick, SUNY- UB

Strand 11: Cultural, Social, and Gender Issues
Symposium - International Perspectives on Multilingual Contexts in Science Education Research and Practice
2:45pm - 4:15pm, Gold Coast
Presenters:
Sonya N. Martin, Seoul National University, Republic of Korea
Philip Clarkson, Australian Catholic University, Australia
Mariona Espinet, Universitat Autònoma de Barcelona, Catalonia, Spain
Laura Valdes-Sanchez, Universitat Autònoma de Barcelona, Catalonia, Spain
Lizette Ramos, University of Guadalajara, Mexico
Sara Wilmes, University of Luxembourg, Luxembourg
Jennifer Park, Seoul National University, Republic of Korea
Alejandro J. Gallard, Georgia Southern University, USA
Hye-Eun Chu, Nanyang Technological University, Singapore
ABSTRACT:
This symposium engages researchers from seven countries to highlight differing foci that can emerge when conducting research on science teaching and learning in multilingual contexts. The first presentation offers a structural framework for other presenters by highlighting some known challenges in the research. The second presentation introduces coteaching as a tool for supporting science and language teachers to effectively collaborate in a community with a difficult linguistic/political/social/cultural history. The third presentation explores co/autoethnography as a methodological and theoretical tool for examining how individuals are positioned relative to language and culture and how these relationships play a role in the shaping the development of researchers and their work. The fourth presentation promotes dialogue about the need for researchers to critically discuss the challenges and consequences of requiring English as a universal language in the sciences, and in the science education research community (including NARST). The final presentation examines challenges facing science teachers in Korea who, for the first time, are in the position of teaching culturally and linguistically diverse students and discusses the challenges faced when conducting research in

multilingual and multicultural contexts. The symposium closes with a whole audience discussion about themes and questions raised during individual presentations.

Strand 12: Educational Technology
Educational Technology in the Elementary Setting
2:45pm - 4:15pm, Comiskey
Presider: Cathy Buntting, University of Waikato

Investigating the Influence of Haptic Technology on Upper Elementary Students' Reasoning about Sinking & Floating
James Minogue, North Carolina State University
David Borland, The University of North Carolina at Chapel Hill
Marc Russo, North Carolina State University
Shengyen T. Chen, North Carolina State University
Ryan Grady, North Carolina State University
ABSTRACT:
This session will chronicle our efforts to build and test a haptically-enhanced simulation for learning about buoyancy. Current haptic technology enables the augmentation of computer-generated visualizations with force feedback, paving the way for “conceptual encounters” with previously unseen and untouched aspects that lie at the heart of many scientific explanations. An emphasis on touch has influenced education throughout its history; some even contend that haptic feedback conjures up experiential or embodied knowledge that would otherwise lie untapped. The 3 –year DR K-12 Exploratory project adopts an informant design approach which actively engages children and local expert STEM teachers design process. The product of this exploratory work to date is the ‘proof-of-concept’ that haptics can be successfully integrated with the Unity platform to build science simulations. Its early research findings are also feeding the development of a local set of design guidelines for the haptic-augmentation of science simulations that can be used by us and perhaps other researchers to scale-up these efforts. This session describes the Year 1 work which includes the iterative development and testing of a haptically-enhanced simulation about sinking and floating (buoyancy).

Digital Science Notebooks as a Means for Assessing Student Understanding Through Drawing and Writing
Angela Shelton, North Carolina State University
Eric N. Wiebe, North Carolina State University
Peter A. Smith, North Carolina State University
Courtney Behrle, North Carolina State University
ABSTRACT:
This study investigates the use of a digital science notebook in 4th grade classrooms to facilitate learning in physical science through both drawing and writing, and use the artifacts as a tool for formative assessment of student conceptual knowledge. This work draws on prior research into the generative effects of both drawing and writing to further conceptual understanding in science and other disciplines. However, less is known as to how this knowledge is distributed between the drawn and written artifacts produced by students, and what the relationship of knowledge assessed here is with traditional summative post-test assessments of knowledge. The primary finding was that students were better able to express conceptual understanding through drawing than through writing. Drawings were similarly more predictive of summative post-test scores. Future work in this project will focus on building machine-based tools for assessing student drawing and writing for formative guidance.